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231.

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF THE SOUTH WALES COAL-FIELD.

PART V.

THE COUNTRY AROUND MERTHYR TYDFIL,

BEING AN ACCOUNT OF THE REGION COMPRISED IN SHEET 231 OF THE MAP.

BY

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PREFACE.

THE country around Merthyr Tydfil, which is described in this, the fifth part of the Memoir on the Geology of the South Wales Coal Field, is illustrated in Sheet 231 of the New Series one-inch map. The Sheet includes a small tract of the Pennant plateau, and the part of the North Crop of the Coal Field which extends from Dowlais to Swansea Vale. The northern half of the map is occupied by the scarps of the Lower Carboniferous Rocks, and by the long dip-slopes of Old Red Sandstone which form the Fforest Fawr and lead up to the Brecknock Fans.

The original survey was made by Sir H. T. De la Beche, Sir W. E. Logan, and Mr. D. H. Williams, on the Old Series One-inch Maps 42 S.W. and 36. The maps are undated, but appear to have been published about 1845.

The re-survey was made on the six-inch scale under the superintendence of Mr. Strahan, and was published in 1900. The south-eastern part of the map was surveyed by Mr. Gibson, the south-western part by Mr. Strahan, and the northern part by Mr. Cantrill. The present volume includes the descriptions furnished by each geologist of the area surveyed by himself, and has been edited by Mr. Strahan.

The Old Red Sandstone includes an upper and impersistent sub-division of grey grits and conglomerates, which is developed round parts of the Carboniferous tract. The grits pass up into the Carboniferous Limestone, and are known from fossil evidence obtained further east in Sheet 232, to be of Upper Old Red Sandstone age. The great mass of Brownstones lying below the grey strata has yielded no fossils in this area, and is doubtfully referred to the Lower Old Red Sandstone. The lowest strata exposed are some green and red sandstones and marls which have been named after the Senni Valley, where they were first distinguished.

The Carboniferous Limestone Series includes the Lower Limestone Shales below the main mass of limestone, and a thin impersistent set of shales with thin dark limestones above that mass. The dark limestones have weathered at the outcrop into rottenstone, and have been dug for that material in the Tawe Valley and west of it.

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Three sub-divisions are made in the Millstone Grit, the most conspicuous member being a massive quartz-conglomerate at the base of the formation. The fossils yielded by some shaly bands show that marine conditions prevailed during the deposition of strata of Coal Measure aspect, but the marine bands observed in the Lower Coal Series of Monmouthshire (Sheet 232) have not been detected in this part of the Coal Field. Upwards the Millstone Grit graduates into the Coal Measures, the upper and lower limits of the Farewell Rock being ill-defined.

The part of the Coal Field included in Sheet 231 illustrates the change in the seams from the condition of steam-coal, as worked near Dowlais and Aberdare, to anthracite, as worked in and west of the Vale of Neath. The change is gradual and affects all the seams—the lower coals being the first to show it—here as in other parts of the Coal Field.

The base of the Pennant is drawn arbitrarily at the Rhondda No. 2 Seam, which becomes the Ynysarwed Seam west of the Neath. There are massive sandstones, however, below that seam, which correspond to the Llynfi Rock of the Maesteg district.

In addition to a large number of normal faults running in the N.N.W. direction, which prevails through the whole Coal Field, two great belts of disturbance, known as the Cribarth and Neath Disturbances, traverse this region from E.N.E. to W.S.W. They form the forerunners of a long series of similar disturbances, which increase in frequency and intensity towards the north-west. All have exercised a marked control upon the river-system, a fact which is well illustrated in the relation of the Tawe and Neath Valleys to the two disturbances named above.

The glacial phenomena shew, both in the distribution of the drifts and in the direction of numerous glacial striæ, that the ice generated on the Old Red Sandstone plateau moved in a general southward direction, surmounting the scarps of the Carboniferous Limestone and Millstone Grit, and crossing deep valleys with little or no deflection. It failed, however, to overtop the great Pennant scarp of Carn Mosyn, but split against it, one part of it moving down the Cynon and Taff valleys in a direction somewhat east of south, while another part turned south-westwards down the Neath and Tawe. Some morainic ridges, lying at the foot of the bolder precipices, appear to have been the last work of the retreating ice-sheet. Several enclose tarns.

The principal economic products, with the exception of the coals, which will be separately described, are summarised i Chapter VIII.

The Map is published in two editions, on one of which (the Solid Edition) glacial deposits are omitted, while on the other (the Superficial Edition), those deposits are shewn by colour, as well as the solid formations where they are not concealed by drift. The six-inch maps illustrative of the Coal Field are in course of publication. MS. copies, both of these and of the maps lying outside the Coal Field, are deposited in this office, where they can be consulted. Copies can be obtained at cost price.

A Geological Bibliography of South Wales and Monmouthshire will be found in "The Country around Cardiff" (Part III. of the Memoir on the Geology of the South Wales Coal Field, 1902.)

J. J. H. TEALL,
Director.

Geological Survey Office,
28, Jermyn Street, London,
20th April, 1904.

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UNIV. OF CALIFORNIA

GEOLOGY
OF THE COUNTRY AROUND
MERTHYR TYDFIL.

CHAPTER I.

INTRODUCTION.

By A. **Strahan.**

Physical Features.

This sheet includes the North Crop of the Coal Field from Dowlais to the Tawe Valley, together with parts of the great Pennant scarp which overlooks it from the south. Towards the north it takes in a large area of the mountain-land of the Old Red Sandstone, known as Fforest Fawr, and reaches in places the water-parting between the Usk on the north and the Taff, Neath, and Tawe on the south. Between these two tracts run the outcrops of the Carboniferous Limestone and Millstone Grit, each, however, shewing in its serrated outline the effects of the various disturbances which will be described in the following pages.

The highest point reached in the Carboniferous area will be found on the Pennant scarp near Carn Mosyn at 1,969 feet. Cefn Pennar, south of Merthyr, shews the same rock at 1,612 feet and Hir Fynydd at the west side of the map, at 1,575 feet. The Millstone Grit rises to a height of 1,832 feet to the west of the Tawe and of 1,866 feet east of the Tâf-fechan, but all the rest of its outcrop ranges from 1,000 to 1,500 feet in height. As a physical feature it is less pronounced than the Pennant scarp, for the ground falls but little to the north of it, and then resumes the gentle rise northwards which characterises the region as a whole. The Old Red Sandstone tract, though intersected by numerous valleys, may be described as a plain rising gently northwards and culminating in a bold scarp of which the most prominent points are Pen-y-Fan, 2,906 feet, and Corn Du, 2,863 feet (both in sheet 213); Fan Fawr, 2,409 feet; Fan Llia, 2,014 feet; Fan Nêdd, 2,177 feet; Fan Gihirych, 2,381 feet; and Fan Hîr, 2,366 feet.

The map shews the upper parts of the drainage basins of the Tâf-fechan, the Tâf-fawr, the Cynon, the Neath or Nêdd with its tributaries the Hepste, Mellte, Perddyn, and Dulais, and the Tawe. The two Taffs and the Cynon follow the south-south-eastern direction which characterises the rivers of the eastern part of the Coal Field.

The Neath and Tawe flow south-westwards, obviously having been induced to follow this course by some remarkable earth-movements which will be described subsequently under the heads of the Neath and Cribarth Disturbances. The scenery of the upper Neath and of the tributaries named above deserves special mention.

Population and Agriculture.

The population is confined chiefly to the valleys. The broad mountain tracts, such as the plateaus of Pennant, the Fforest Fawr, and in a less degree the Millstone Grit and Limestone outcrops are almost uninhabited. The valleys of the two Taffs and the Cynon on the other hand are more or less inhabited throughout, and where they enter the Coal Measure area are occupied by such towns as Merthyr and Aberdare with a number of populous villages. Dowlais and Hirwaun, however, lie in no main valley but have grown on the spots where labour was in requisition. The water-supply is obtained locally from springs, which in such a region are of almost infinite number and variety. The Old Red Sandstone tract is utilised as a source of water for Merthyr, Cardiff, and Swansea. A high elevation and copious rainfall, the scarcity of houses and cultivation and the composition of the rock combine in rendering the tract suitable for the yielding of pure surface-water.

A large proportion of the region is devoted to sheep-farming. The Old Red Sandstone grows chiefly rank grass with but little heather, and the limestone, where not actually bare, is so much covered by a glacial drift composed of Old Red detritus, as to simulate the soil of the Old Red outcrop. The lower subdivision of the Millstone Grit, a coarse grit full of quartz-pebbles, yields some of the poorest land, and is, in fact, often wholly devoid of both soil and vegetation. Cultivation has extended scarcely beyond the outcrop of the lower and shaly parts of the Coal Measures, and is confined chiefly to the growing of such crops as the farmer requires for his own use. Under certain circumstances the soil produced by the decomposition of the muddy Pennant sandstone is capable of yielding excellent results.

Table of Strata and Classification.

The formations enumerated in the following table are distinguished by colour upon the map :—

Peat Alluvium Alluvial Fans River Gravels (Terraces)	Recent and post-Glacial
Boulder Clay and associated Sand and Gravel	Glacial
Pennant Series with the No. 2 Rhondda Seam at its base The Lower Coal Series with some of the principal sandstones in its upper part	Coal Measures

Farewell Rock		Millstone Grit
Shales		
Quartz Conglomerate		
Limestone with bands of sandstone and quartz-conglomerate		Carboniferous Limestone Series
Shale	Lower Limestone Shales.	
Limestone		
Grey Grits and Conglomerates		Old Red Sandstone
Red Sandstones and Marls (Brownstones and Senni Beds)		

The seam here known as No. 2 Rhondda corresponds to that which is known as the Tillery Vein further east, and which is there taken as the base of the Pennant.* Some sandstones below it, however, develop westwards and in the region under description have assumed such importance as occasionally to make a more conspicuous feature in the landscape than the rock above it. They correspond in a general way with the sandstones which have been described under the name of the Llynfi Rock in the Ogmore, Garw, and Llynfi Valleys.†

The base of the Coal Measures is drawn so as to include not only the lowest coal-seam but the lowest "mine-ground," or shales with clay-ironstone, which are closely associated with the coals. The lowest ironstones are known as the Rosser Veins and lie close upon the Farewell Rock.

The uppermost division of the Old Red Sandstone, the Grey Grits and Conglomerates, falls far short of the development it attained on the east and south sides of the Coal Field, and in fact ceases to exist in parts of the region under description. Nearly all the remainder of the Old Red tract is occupied by the red sandstones of the Brownstone subdivision, but a thick and persistent group of sandstones and marls with cornstones, generally characterised by a green colour, appears in some of the deeper valleys, among others that of the Senni, from which fact the name of Senni Beds has been applied to them. Though bands of marl occur in abundance in the Brownstones, the marls with cornstones which constitute the lowest subdivision of the Old Red Sandstone nowhere reaches the surface within the limits of this map. A traverse made from north to south will show the formations named above in ascending order in any part of the map with one notable exception. A deep gash, bounded by trough-faults, traverses the Old Red region and passes thence as a complicated crush-zone down the Vale of Neath, whence it gains its name of the Neath Disturbance. Along it the rocks are shifted some few miles out of their proper line of outcrop. The description of this and of the closely related Cribarth Disturbance, together with that of a number of normal north-north-west faults, is reserved for a separate chapter.

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* Geology of the Country around Abergavenny (*Geol. Survey Memoir*), 1900, p. 49.

† Geology of the Country around Pontypridd (*Geol. Survey Memoir*), 1903, p. 30.

The glacial phenomena exhibited within the area under description are of no little interest. Glacial deposits and striated rock-surfaces abound, and furnish convincing proof that an ice-flow from the Brecknock water-parting traversed the region in a general southward direction, but that while it crossed minor features such as the escarpment of the Millstone Grit and the ravines of the Mellte and Perddyn, it found the Pennant scarp of Carn Mosyn insuperable. Here therefore it divided, a part following the Taff system while the remainder turned westwards down the Neath and Tawe.

CHAPTER II.

OLD RED SANDSTONE.

Introduction.

By T. C. Cantrill.

The Old Red Sandstone in the ground under description consists of the following subdivisions in descending order:—

	Ft.
Grey Grits and Conglomerates	0 to 200
Brownstones	1,400 to 1,500
Senni Beds, probably	1,000

Senni Beds.—The lowest Old Red beds exposed within the area of the map occur at the heads of Glyn Tarell, Glyn Senni, and Glyn Tawe, and in the valley of the Dringarth. They consist of rapid alternations of pale-green and dull-red sandstones, shales, and marls, with numerous thin green and red conglomeratic cornstones. Lithologically the subdivision is closely allied to the Brownstone series, but the presence of the cornstones links it with the underlying Red Marls. On the one-inch map it has not been distinguished by colour from the Brownstones, though on the six-inch office-copies a divisional line has been drawn.

Broadly, the Senni Beds are distinguished from the Brownstones by the frequency of green colour, which is, however, liable to pass horizontally into red, while the red tints are usually dull, and graduate into chocolate and purple. Mica-flakes are frequently present on the bedding-planes. Numerous beds of conglomeratic cornstones occur, but these are rarely above two feet thick, and have nowhere been seen to exceed six feet. Some of the marls contain small pea-sized pellets of calcareous matter or 'race,' and may then be regarded as extremely argillaceous cornstones. Some of the more micaceous flaggy sandstones have been worked to some extent for roofing, paving, and monumental purposes.

The base of the subdivision is nowhere reached within the region under description, but from observations farther west its thickness must be at least 1,000 feet.

The Senni Beds pass conformably upwards into the overlying subdivision. They have yielded no fossils beyond a few indefinite plant-remains in the Dringarth Valley (p. 9).

The olive-green colour of much of the sandstone in this subdivision seems to be explained by the following note by Mr. H. H. Thomas:—

Green sandstone, Senni Beds; from brook-section, 170 yards N.W. of Altitude Point 1,319 at head of Glyn Tarell; six-inch map, Brecknock 33 S.W., one-inch map, new series, 231.

A dark olive-green sandstone, hard and compact, including some small rolled fragments of a darker-coloured green marl.

Treated with acid, the insoluble residue is seen under the microscope to contain, besides the quartz which makes up the greater part of the mass, a dark-green chlorite in considerable quantity, associated with a yellow epidote. Both these are decomposition-products of some ferro-magnesian minerals, probably biotite and hornblende. The chloritic mineral gives the colour to the rock. Decomposition of the ferro-magnesian minerals has probably gone on to some extent since the sediment was laid down, for the green staining has extended into the adjacent minerals. Among the other heavier minerals muscovite is the mica which makes itself evident in the hand-specimen; unaltered biotite also is present. Tourmaline occurs in well-formed crystals of a deep-brown or black colour. Zircons are plentiful and well shaped; they occur also included in the chlorite and muscovite. Rutile is present as deep amber-coloured grains. Orthoclase in fairly fresh grains is rare, but a large quantity of rotten felspar, probably mostly plagioclase, is present. The silica is all detrital. There are no secondary growths.

Brownstones.—This name was employed by the Rev. W. S. Symonds to designate the great series of rapidly-alternating red and brown sandstones, shales, and marls, which follows on the beds last described. The subdivision is characterised by impersistent, massive, coarse sandstones in the lower and middle parts, and by hard red sandstones with pebbly horizons in the uppermost parts, as expressed in the following table:—

	FT.
Red sandstones; tough, gritty, flaggy, with occasional quartz pebbles; they contain thin bands of shale, and, at their base, impersistent pebbly red quartzitic grits and conglomerates. These rocks give rise to the plateau-scenery which forms a characteristic feature of the Old Red country - - - - -	20-50
Red marls, shales, and sandstones, thin-bedded and rapidly alternating; thicker-bedded towards middle and lower parts, with pebbly, coarse, thick, and massive incoherent sandstones (Blaen-y-glyn, Llyn y Fan Fawr). Thickness estimated in Glyn Tawe (p. 7) to amount to - - - - - - - -	1,400
	1,450

Though the gradation from the one group into the other is complete, the uppermost division—the plateau-beds—is easily recognised, as it has given rise to the characteristic scenery of the Brecon Beacons and Carmarthen Fans, namely, long dip-slopes leading gently upwards from the south and terminating in a precipitous escarpment. These pebbly beds have frequently been referred to by previous writers as the Old Red Conglomerate subdivision; but they occur below the Grey Grits to which the most conspicuous conglomerates of other parts of South Wales belong. Most of their outcrops are indicated by the words 'Pebbly Grit' on the one-inch map.

The Brownstones present a variety of lithological types. Many of the sandstones are fine-grained and purplish in colour; some are flaggy, and have been wrought for roofing and paving; some are ripple-marked, while others again are massive, thick-bedded, and pebbly. Some of the sandstones contain rolled nodules of red marl, derived probably from the destruction of a neighbouring marl-bed.

The massive coarse sandstones with quartz-pebbles met with towards the middle and base frequently assume a remarkable gnarled appearance on weathering. The base of the group which forms the plateaus is marked by impersistent pebbly red grits and sandstones, in bands ten feet or less in thickness, split up by and passing laterally into non-pebbly grit. The pebbles are usually of white and of red vein-quartz, with a few of quartzite and bright-red jasper-like rock; they generally fall short of an inch in length, though there are a few as large as a hen's egg. The hard red sandstones above this conglomeratic horizon contain large rounded grains and occasional pebbles of quartz, and are sometimes markedly current-bedded.

The marls and shales are often bright-red in colour; and being somewhat sandy do not usually weather down into clays. Some are charged with calcareous pellets ('race'), and thus pass into conglomeratic cornstones. Thin and impersistent bands of the latter rock occur, usually less than one foot, and never more than six feet, thick. The marls alternate with sandstones, usually not more than ten to fifteen feet thick, and thus give rise to innumerable small cascades and waterfalls.

No fossils except a few indefinite traces of plants and an occassional worm-track have been met with.

All the valleys draining southwards from the Fan range exhibit sections, the finest exposures occurring among the eroded plateaus east of the Tâf Fawr, and along the face of the escarpment of the Fans, much of which, however, lies beyond the northern limit of the map.

The thickness of the Brownstones in the Tawe Valley from the base of the plateau-beds to the the top of the Senni Beds has been determined approximately by observations made at the foot of Fan Hîr. Between the top of the Senni Beds, as seen near the mouth of Nant y Coedcae, and a pebbly grit exposed in the upper part of that stream, there are about 500 feet of strata. The outcrop of that grit, if it runs in accordance with the dips observable in the hillside, will intersect a line drawn in the direction of dip through the Trigonometrical Station on the top of the Fan, at a distance of 600 yards from the Station. Allowing for a dip of about 15° and for the slope of the ground, we get here room for another 900 feet up to the base of the plateau-beds. The thickness of the plateau-beds is about 50 feet, which gives a total for the Brownstones of some 1,450 feet.

The Senni Beds, if present at all in the Newport and Abergavenny districts, have probably been included in the Brownstones, which at Blorenge are about 1,200 feet thick. From observations made farther west in Sheet 230, the Senni Beds which immediately overlie the lowest or Red Marl subdivision of the Old Red Sandstone cannot be much less than 1,000 feet. It thus becomes clear that the Brownstones thicken not only westwards but also from south to north.

Grey Grits.—These are a thin series of grey, yellow, and olive-coloured sandstones and grits (hard siliceous sandstones), usually containing pebbles of white vein-quartz. When the pebbles are sufficiently numerous, the rock becomes a quartz-conglomerate indistinguishable in outward appearance from that at the base of the Millstone Grit. It contains occasional thin bands of red sandstone and marl, but no cornstones so far as is known. The Grey Grits sometimes give rise at or near their base to ferruginous springs, some of which appear to contain sulphides. Their base as traced on the map has generally been drawn so as to include all the grey rocks; in some places it is defined by an abrupt change of colour, but elsewhere red and grey beds alternate. The rocks are well exposed at the Carboniferous outlier of Bryniau Gleision, and at the head of Cwm Llysieuog.

During the course of the present survey, the question has frequently arisen as to whether or not the Grey Grits should be grouped with the Carboniferous system. Not only is there a passage from them up into the Carboniferous Limestone, but the more pebbly varieties closely resemble both the grits and the conglomerates within the limestone, and also the basement beds of the Millstone Grit. We find also some little evidence of thinning-out, and possibly erosion, at their base (p. 16); while further west (Sheet 230) they appear to overstep or overlap the plateau-beds and to pass on to somewhat lower horizons of the Old Red Sandstone. These facts and the cessation of the red colour taken together seem to favour the view that the Grey Grits should be regarded as a sandy basement of the Carboniferous series. It may be however that the olive-coloured sandstones east of the River Hepste represent the highest beds of Old Red Sandstone, while the feebly developed pebbly grey grits west of that river should be regarded as the base of the Carboniferous System.

The Senni Beds.

By T. C. CANTRILL.

The Senni Beds come within the limits of the Sheet under description in Glyn Tarell at about a mile north-west of the Storey Arms at the head of Cwm Tâf Fawr. The dull-red and green sandstones, shales, and marls, with their conglomeratic cornstones, are well displayed in the lower part of a cliff overhanging the Brecon and Merthyr road and in the tributaries of the Tarell. Opposite a peat-flat a quarry shown on the map by a dip-arrow affords a section of thin-bedded sandstone and marl overlying hard brown and grey sandstone. The latter is worked for roadstone and is exposed for 15 feet.

Nant y Gwair, Nant Mawr, and Nant y Gaseg in the Dringarth Valley traverse similar beds, with cornstones ranging up to three feet in thickness; and eighty yards south of the confluence of Nants Gwair and Gaseg the eastern bank of the stream shows red, dark-green, and black shales, the latter containing indefinite traces of plants. This tract of Senni Beds appears to be an inlier surrounded on all sides by Brownstones.

In Glyn Senni, notably above Tyle-glâs in the cascades of Nant Ystwyth, the beds are almost exclusively green in colour. There are good exposures in the lower parts of the Llethr, where a bed of red sandstone weathering in a peculiar gnarled fashion serves as the base of the Brownstones, whilst immediately below are red and green sandstones with cornstones; a rounded pebble of brownish-red grit was noticed in one of the cornstones. When followed westwards of this point, the green colour seems to give place to various tints of red and purple; thin cornstones are still present. Nant Cil y Fforch west of Pen-tŵyn exhibits green beds, with cornstones up to six feet thick.

At the eastern edge of Fan Bwlch Chwŷth on the adjacent map to the north (Sheet 213), some micaceous green flaggy sandstones belonging to this subdivision are occasionally wrought for paving, roofing, and tombstone purposes; and there are small quarries on the same horizon near the roadside half a mile east of Tyle-garw.

The Senni Beds form a tongue running up Cwm Crai and Nant Gihirych, but are greatly obscured by drift. A thin band of fine-grained calcareous sandstone of a sage-green colour crops out in the bed of Nant Gihirych a few feet below the top of the Senni Beds at the point marked by a dip-arrow of 10° on the map. The rock contains numerous small darker fragments visible to the naked eye. Dr. Flett describes a microscopic slice (E. 3,400) of the rock as follows:—

> Fine greenish calcareous sandstone with shreds of plant-tissues. Small angular and sub-angular grains of quartz, and scales of colourless mica, are cemented by a material which is partly calcareous, partly micaceous and argillaceous. The rock contains also finely-divided chlorite and stains of limonite. Some of the pebbles are granular, slightly siliceous limestone, and others seem to be chert. Irregular fragments with woody structure, more or less disintegrated and calcified, lie scattered through the section.*

At the northern end of Cefn Cûl, green cornstones occur in association with green sandstones, and the latter have been quarried for flags. In the upper part of the Tawe Valley near the Maen Mawr there are numerous exposures of these rocks but west of it the outcrop of the Senni Beds passes northwards beyond the limit of the map.

The Brownstones.

By T. C. CANTRILL.

One of the finest exhibitions of the characteristic scenery of the Brownstones may be seen from the northern edge of Bryniau Gleision. On the far side of the deep Glyn Collwng a plateau formed by the hard uppermost rocks slopes gently upwards to the north to a height of nearly 3,000 feet. Though once continuous, this long slope has been deeply trenched by stream-action into separate hill-masses, each with a flat top bordered by precipitous escarpments. These great physical features were admirably expressed on the old series Ordnance Map (Sheet 42 S.W.)

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* Mr. Newton confirms the woody nature of many of the dark specks.

Glyn Collwng cuts down deeply into the Brownstones. Some waterfalls at Blaen-y-glyn are due to a thick massive sandstone and above this point both the Gyrfanell and Bwrefwr show an ascending succession of alternating marls and shales with sandstones, the whole capped by the harder rocks of the plateau. The latter are excellently exhibited in the long lines of precipitous crags around the edges of many small tablelands, and also along the main line of the Brownstone escarpment at the heads of Cwm Oergwm and Cwm Cynwyn.

In Cwm Callan the beds have been greatly affected by the Vale of Neath disturbance, as will be described on p. 86. South-east of Neuadd several thin cornstones are exposed in the streams. On the sides of the Tâf Fechan valley, and in the bed of the river northwards of the reservoir at Dol-y-gaer, are numerous sections of the middle part of the Brownstones, and east of the reservoir the highest beds may be seen interbedded with the Grey Grits, though the hard red grits which form the plateaus are not recognisable. On Craig Cwm Oergwm at 2,000 yards north-west of the dip-arrow shown on the map there is an old quarry in purple-red flags, and a similar rock has been wrought two-thirds of a mile farther south-east.

On the moorland north of Torpantau are some exposures of light-red coarse sandstone and grits with quartz-pebbles, and similar beds occur west of the Tâf Fechan at the head of Nant Ddu. They probably belong to the plateau-beds.

Pen y Fan, 2,906 feet, and Corn Du, 2,863 feet, better known as the Beacons of Brecon, although somewhat beyond the northern edge of the map, deserve mention here. Each supports a small but characteristic outlier of the plateau-beds, consisting of well-bedded flaggy red sandstone, in which occur a few scattered quartz-pebbles. The rock of the outliers, which dips about S.S.E. at 2° to 3°, rests on a great series of marls, shales, and sandstones exposed in the precipices of Craig Cwm Llŵch, Craig Cwm Seri, and Craig Cwm Oergwm. It can hardly be more than ten or twenty feet below the horizon of the base of the Grey Grits. In the Tâf Fawr valley nearly horizontal red sandstones, shales, and marls are well shown at the south-west end of the dam of the reservoir half a mile above the village of Nant-ddu.

On the moorland north of Gwaen Crew the plateau-beds are represented by loose blocks of pebbly grit, and they form the narrow ridge of Cefn Cûl, which separates Cwm Crew from the Tâf Fechan valley. A mile north-north-west of the latter ridge, and just south of Bwlch Duwynt, they show marked examples of fan-bedding, the planes dipping N.N.W. at 20°.

It is doubtful whether the plateau-beds exist round the outlier of Grey Grits on Waen Llysieuog. Some red sandstones which form waterfalls at the head of the Cwm of that name, and to which a feature close below the Grey Grit may be attributed, may represent them, but they seem to be devoid of pebbles.

West of the Tâf Fawr valley, Bryn Du and the northern slope of Fan Fawr present crags of coarse, gritty, dull-red sandstone belonging to the lower beds of the Brownstones, and exhibiting examples of gnarled weathering; while the precipitous eastern scarp of Fan Fawr is formed by the rocks belonging to the middle part of the subdivision. The Brownstone base, though ill-defined, appears to pass up the eastern side of Glyn Tarell and to cross the turnpike road about 300 yards north-west of the eighth milestone from Brecon, and then to ascend the cliff in a west-north-west direction towards the head of Nant y Gwair.

West of the village of Nant-ddu the Carboniferous rocks rest directly upon red pebbly grits which belong to the plateau-beds. A knoll known as Carn Caniedydd, and the banks of the Hepste above and below its junction with Nant y Cwrier, show this same red rock.

In the Dringarth valley the base of the Brownstones has been drawn at the bottom of some pebbly, coarse, red sandstone exposed in the river at a quarter of a mile south of Nant Mawr. It crosses the latter brook about half a mile above its mouth; thence loops round the head of Nants Gwair and Gaseg, and returns again to the Dringarth, thus enclosing the inlier referred to on p. 9. Southwards the river exposes the middle portions of the Brownstones, and passes on to the pebbly red plateau-beds 300 yards south-south-east of Tycanol; south of Pen-fathor-isaf the plateau-beds are seen again, and occur evidently at a few yards only below the base of the Carboniferous series.

West of the Dringarth valley the middle portions of the Brownstones form the main mass of Fans Llia and Dringarth, and may be examined in a landslip on the eastern side of the latter. The plateau-beds are exposed in the river Llia at Aber-Llia. A brown grit lies next below the Lower Limestone, and is followed in descending order by purple grit seen in the river. The brook from Plâs-y-gors exposes red and purple grits, but in none of these rocks were pebbles observed. The bed of the Llia farther north lies upon lower horizons. A cornstone one foot thick associated with red sandstone and shale crops out 100 yards south of the mouth of Nant y Groes. Still farther up, in two streams eastwards of Maen Llia,* there are several other thin bands, associated with red micaceous sandstone. These rocks strongly resemble the Senni Beds, of which, in fact, they may form an inlier.

Some coarse red sandstones which form the base of the Brownstones at the head of the Llia valley exhibit the gnarled weathering which has been already mentioned; blocks of this rock lie in the southern angle between Nant Ystwyth and the main road over Bryn Melyn, and it occurs in place by the side of the Sarn Helen, fifty yards north of the altitude point 1,468 on the map; while a similar bed is exposed 300 yards west of Maen Llia. The base of the Brownstones enters the map about 100 yards east of the main road over Bryn Melyn; crosses Nant Ystwyth 250 yards above the road, and the Sarn Helen at its upper elbow; continuing thence along the Llethr, it passes round the head of the Senni valley and across Nant Cil y Fforch, nearly following the 1,500 contour. North of the last-named stream the lowest Brownstones consist of false-bedded coarse red sandstones which form a feature immediately west of a quarry in the Senni Beds (p. 9).

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* This is an irregular block of red conglomeratic cornstone, 12 feet high, 9 feet broad, and 2 feet 6 inches thick, set up on end within a few yards of the Sarn Helen.

In Fan Nêdd we find another great hill-mass formed of the Brownstones. The precipitous northern face yields numerous exposures, while the moorland south of the summit shows pebbly plateau-beds. Hard red sandstones overlying four feet of pebbly grit crop out in the Neath at a point shown on the map by a dip of 15°. Rocks assignable to the plateau-beds are exposed in Nant y Môch, and form a good escarpment on Fan Fraith. Here they are thrown down to the north by the Cribarth Disturbance (p. 93), but rising again they form a crag at the top of Fan Gihirych, in which are shown about 18 feet of red sandstone resting on six feet of pebbly red grit.

On both sides of the Upper Byfre, north of Carn yr Onen, there are bare slopes and crags of pebbly rocks assignable to the plateau-beds and lying not more than 20 or 30 feet below the base of the Grey Grits. The underlying softer beds are exposed farther up stream.

The Tawe valley and its tributaries afford good exposures. Nant Byfre, south-east of Capel Callwen, gives an opportunity of seeing the close relationship of the Carboniferous and Old Red systems. Higher up the dingle the Grey Grits (p. 17) overlie hard red sandstones and grits dipping west at 30°-35°. The middle parts of the Brownstones are shown in numerous brooks flowing down the eastern side of the Tawyneu valley, in the bed of the latter stream, and in the upper parts of Cwm Crai, while in both the latter valley and in Nant Gihirych the Senni Beds come to the surface. The base of the Brownstones crosses the northern tributary of Nant Gihirych at the dip-arrow shown on the map, where red sandstone rests on green sandstone and cornstone. It then crosses Nant Gihirych near the 1,250 contour and descends into Cwm Crai, whence it ranges in a north-westerly direction up the western side of the valley. A dip of 15° on the map marks the outcrop of some green sandstone and cornstone not far below the lowest pebbly sandstones of the Brownstones. The base then passing round the northern end of Cefn Cûl turns southwards into the Tawe valley. Cefn Cûl itself consists of the middle mass of the Brownstones.

The River Tawe exposes various sandstones and marls. A small quarry has been opened in red sandstone 250 yards north of Blaen-Car. The Brownstone base on descending from the north end of Cefn Cûl crosses the river at the mouth of Nant y Llyn, follows that stream upwards for about 300 yards, and then turns north-north-west, passing within seventy yards west of Maen Mawr. A short distance farther on it meets a fault by which it is thrown a mile southwards, to a point 120 yards below the mouth of Nant y Coedcae, but from this point it again runs northwards, keeping at 70 to 150 yards west of the fault. It crosses Nant y Llyn thirty yards above the dip-arrow shown on the map, where green sandstones which form a waterfall pass upwards into some red shales and sandstones, which appear to form the base of the Brownstones. A red cornstone six feet thick occurs in the Brownstones in Nant y Coedcae about 270 yards above its mouth.

An almost continuous section of the Brownstones can be obtained by working up Nant y Llyn on the west side of the fault. The lower beds consist of red marls and sandstones, the latter being thick enough to form small cascades and waterfalls. Next follows a belt of pebbly coarse incoherent sandstones, which crop out immediately south of Llyn y Fan Fawr (a little north of the edge of the map); these are traceable southwards along the flat ground at the foot of Fan Hîr, and lie between 800 and 900 feet below the base of the Grey Grits. Above this pebbly belt succeed the marls with sandstones which make up the great mural scarp of Fan Hîr, and these again are crowned by an inaccessible cliff of the plateau-beds which extend from the edge of the map southwards for about a mile. At the Trigonometrical Station, 2366, the cliff consists of thirty to forty feet of hard red sandstone with occasional quartz-pebbles, underlain by about four or five feet of conglomerate which crops out continuously for some distance. Below this comes the great mass of marls and sandstones previously mentioned. A quarter of a mile farther south the pebbly grit runs out onto the dip-slope, where it breaks down into innumerable blocks. It consists of a hard quartzitic red matrix containing pebbles of white and of pinkish-white vein-quartz, with some of a bright-red jasper-like rock, and others of brown quartzite. Some of the pebbles attain the size of hen's eggs, and appear to be larger here than elsewhere. The plateau-beds of Fan Hîr appear to form a long narrow outlier, bounded by a steep slope along the western side.

The Haffes for about a mile above its delta flows along the outcrop of the higher beds of the Brownstones. A pebbly grit, six feet thick, belonging to the plateau-beds crops out on the south side of the valley 200 yards above the mouth of Trawsnant-isaf, while the underlying sandstones and marls form the bed of the river. At the waterfall, 'Sgwd Du, shown on the map by a dip-arrow, the plateau-beds consist of thirty to forty feet of thin-bedded hard red sandstones with some few pebbles, but the well-marked conglomerates of Fan Hîr seem to be absent. Some low river-cliffs 200 yards north of the dip of 15° expose the same rocks, as shown in the following sections:—

On the Haffes; west of the Fault.

	FT.	IN.
Sandstone, hard, red, with quartz-pebbles - -	5	0
Red marls - - - - - - - - - - -	4	6
Quartz-conglomerate, red - - - - - -	1	6
Sandstone, red, with a few pebbles at top		

Fifty yards farther up stream the cliff shows :—

	Ft.	In.
Pebbly grit	4	0
Marls	4	0
Sandstone	10	0
Marls	6	0

To these pebbly grits also are due some bare dip-slopes on Cefn Rhudd, and others conspicuously glaciated, along the west side of the Giedd Fâch; another, west of Mawnog Carnau Gwys, appears to lie not more than twenty or thirty feet below the Grey Grits. The river Twrch, which flows along a syncline, repeatedly exposes these rocks, and some bare dip-slopes on Breast Twrch again bear witness to their stubborn character.

The great escarpment known as Banau Sir Gaer, which reaches a height of 2,631 feet in Banau Brycheiniog, and of 2,460 feet in Picws Du, lies north of the edge of the map, but gives the continuation of the scarp of Fan Hîr. The scarp-slope, as in the case of Fan Hîr, consists of rapidly alternating marls, shales, and sandstones, but is capped at its highest points by pebbly grits belonging to the plateau-beds. At the northern end of Fan Hîr the pebbly grit runs out onto the dip-slope at about 400 yards south of Bwlch y Giedd. North-westwards of this point it is not seen, but blocks of a similar rock occur on the western edge of Fan Foel. Bwlch Blaen Twrch cuts down well below its horizon; but west of the Bwlch the pebbly grit sets in again and forms the highest parts of the scarp, apparently as an outlier bounded by a steep feature along the south side. Cwâr Du Mawr, the cliff overlooking the south-eastern corner of Llyn y Fan Fâch, shows it to a thickness of 20 feet, with the great mass of marls and sandstones beneath. A little west of this point the pebbly grit runs out onto the dip-slope, but comes in again, directly south of the Llyn, for a distance of some 200 yards; beyond this it is cut off by a small fault with easterly downthrow, which runs down Gwtter Gôch and has caused bleaching and disturbance of the rocks. One hundred yards farther on, however, the pebbly grits come in again and form a bold cliff overhanging the western side of the Llyn. Beyond this point the ground fails to reach them, and their outcrop turns south-westwards into the valley of the Twrch Fechan.

The Grey Grits.

By W. Gibson.

South of the Neath Disturbance.—On the east side of the Tâf Fechan the Grey Grits and the beds below them form the featureless slopes of Buarth y Caerau, and are well exposed in Cwm Criban. Near the head of the cwm the stream descends over an impure limestone containing a few quartz-pebbles on to hard grey pebbly grits. Further down, and about 500 yards east of the railway, the grits rest on brown sandstones and mottled red marls, which being comparatively soft give rise to a waterfall. The remainder of the ravine affords a good view of similar red Brownstones. Between here and Pontsticill Station the outcrop of the Grey Grits can be readily traced, but on Buarth y Caerau their base is uncertain.

On the west side of the Tâf Fechan the brown sandstones and mottled marls have been deeply trenched by Nant Car Fâch, south of Capel Tâf Fechan. In the hill to the north they can be traced close up to the southernmost fault of the Neath Disturbance, by which they are brought against the main Carboniferous Limestone, the junction of the two formations being indicated by a spring. The beds dip northwards towards the disturbed belt, and only resume the normal southerly dip at a distance of half a mile from it. The Neath Disturbance, therefore, in this part of its course combines a synclinal structure with that of a faulted trough (p. 26).

The plateau between the Tâf Fechan and the Tâf Fawr is strewn with blocks of the Grey Grits, but the solid rock is to be seen only near Twyn Croes and in a stream-course west of Bryn-Glâs. The position of the base, moreover, is conjectural, for the underlying Brownstones are overspread by peat.

On the east side of the Tâf Valley the junction of the grey and red rocks is visible in a side-stream north of Grawen, but northwards the outcrops are buried under Boulder Clay. The chief exposures on the west side are afforded by some streams near Pen-twyn-isaf. Thin beds of grey grit are here interbedded with the red sandstones and marls, showing that no hard and fast line exists between the two groups. Grey grits crop out in several places to the east and north of Pant Sych Pant and the plateau is strewn with blocks of a similar character. The strata dip southwards at an angle which averages 10°, but increases to 20° near the Neath Disturbance, while 500 yards south-south-east of Pen-yr-heol the red grits below are nearly vertical. The synclinal arrangement noticed in the Tâf Fechan no longer exists, but that the strata in the disturbed belt are sharply folded is certain, for in Nant Car Fawr the Grey Grits dip to the north-west at 20°, while 200 yards to the north the dip is south-south-east at 30°.

North of the Neath Disturbance.—North of the disturbance the beds rise northwards at a gentle angle which nearly coincides with the slope of the ground, and therefore form wide outcrops; but the plateau is covered with long grass, swamps, and small peat-bogs, so that sections are confined to the streams. In Nant Gwineu on the east side of the Tâf a very hard grey grit is exposed at intervals, and without doubt covers a considerable area on Cefn Ynys-fawr, though it is never visible. The stream in its lower part cuts down to the underlying red grits, and these rocks are seen in the bed of the Tâf to retain an almost horizontal position to within a few feet of the northernmost of the Neath faults near Pont-ar-Dâf. On the west side of the Tâf, in Nant Garw Fawr, the red and overlying Grey Grits have given rise to a series of waterfalls. About 15 feet of grey grit forms the upper part of the falls, and a similar rock crops out along the bed of the stream for about 700 yards westwards.

Within less than a mile to the north, however, the Grey Grits disappear; the Lower Limestone of Cefn Esgair Carnau rests directly on a red pebbly grit, and again in the Hepste near its junction with Nant y Cwrier, the same limestone, though it contains a thin bed of grey grit, rests directly on red grits. Whether the disappearance is due to overlap by the limestone, or to the dying out of the Grey Grits, or to the grey rock having passed laterally into red rock, is uncertain.

The Grey Grits (*continued*).

By T. C. CANTRILL.

The Grey Grits are well exposed around the Carboniferous outlier of Bryniau Gleision. On Daren Fawr they are about 40 feet thick and rest with a definite base on red sandstone and marls. They have been quarried at Blaen Callan Farm and also on the edge of the plateau above Dan-yr-allt, where they consist of greenish-grey flags, interbedded with the uppermost Brownstones. As the pebbly plateau-beds of the moorlands a few miles to the north (p. 10) could not be found here, it seems likely that the Grey Grits rest on a somewhat lower horizon of the Brownstones.

A large outlier of the Grey Grits occupies Waen Llysieuog but its limits are obscured by peat. The position of the base can be fixed approximately in the component streams of Nant Llysieuog by the presence of features and innumerable blocks.

West of the Tâf Fawr they are to be seen west of Pen-tŵyn-uchaf and appear to be faulted down against red sandstones on the west.

North-west of Nant Garw Fawr and Pant y Wern the Lower Limestone follows so closely upon the red pebbly grits or plateau-beds of the Brownstones (p. 11) that there seems to be no room for any Grey Grits, and certainly none are exposed. Moreover to the west of this locality they are so thin and their exposures are so disconnected that their outcrop has not been laid down on the one-inch map. It would appear, therefore, that they thin out or were deposited in patches only over part of this region.

In the Dringarth Valley a brook north of Pen-fathor-uchaf shows two or three feet of grey and yellowish slightly calcareous sandstone between the Lower Limestone and the purple and red sandstones of the Brownstones; and on the eastern edge of the alluvium of the Dringarth north-east of the ruins of Castell Côch several feet of grey grits with quartz-pebbles are exposed in the side of an old millrace; they lie immediately below the Lower Limestone and overlie purple sandstone and grit exposed a few yards farther to the north-east.

There appears to be a trace of grey grit or very sandy limestone a foot or so thick at the base of the Lower Limestone in the river at Aber Llia; a trace also occurs in a similar position in the brook at Plâs-y-gors. The next exposure is yielded by a small brook rising in a swamp a few yards west of Maen Madoc and flowing into the Nêdd. The section is as follows, in descending order:—

Section near Maen Madoc.

		Ft.
Lower Limestone Shales	Shales with thin limestones	
	Lower Limestone—sandy and pebbly	20
Grey Grits	Greenish-grey grit	3
Brownstones	Purple grit, seen to	10

Lower down the Nêdd Valley, at a bend in the lane 250 yards north-north-east of Coed-y-gareg, some gritty detritus nearly in place shows through the Boulder Clay, and indicates the close proximity of the outcrop of some grey grit. Olive-green grits, probably not more than 10 feet thick, are exposed under Glacial Drift in a brook east of Carn yr Onen, and some loose blocks north-west of Pwll Byfre indicate an outcrop of yellow sandstone. In the Lower Byfre south-east of Capel Callwen the following measurements were obtained:—

Section in Nant Byfre.

		Ft.	In.
Lower Limestone Shales.			
Grey Grits, 24 Ft.	Grit, hard, blue-grey, slightly calcareous	7	0
	The same with small white quartz-pebbles, giving place laterally to blue sandy marl	6	0
	Sandstone, dark-grey, softer, not calcareous	4	6
	Grit, hard, greenish-grey, seen to 3 feet, and probably extending downwards to	6	6
Brownstones.			

From this section and the others farther eastward it is clear that the Grey Grits, though absent in the Hepste Valley, come in again between that river and the Dringarth, and gradually thicken westwards.

There are one or two exposures of pebbly olive-green grit on the southern brow of Cwm Haffes. The outcrop crosses the river 80 yards above the waterfall 'Sgwd Du, and shows pebbly white quartz-grit and green flaggy grits, some of which exhibit markings due possibly to worm-burrows.

Where the outcrop of the Grey Grits crosses the Giedd the ground is greatly obscured by drift. The highest Brownstones are succeeded by buff flaggy marls followed by buff shales, but whether these represent the Grey Grits or belong to the Lower Limestone Shales is uncertain.

That a pebbly white grit exists along the southern margin of Mawnog Carnau Gŵys is indicated by the presence of numerous blocks, and that rock is seen resting on red sandstones and marls at the mouth of Nant Lluestau, in the Twrch Valley. At the mouth of the Twrch Fechan, in the adjacent Sheet 230, the Grey Grits are about 15 or 20 feet thick.

Several other exposures of the Grey Grits more or less abnormal in position will be referred to in connection with the descriptions of the Vale of Neath and the Cribarth Disturbances (pp. 86, 92).

The Grey Grits, generally at or near their base, give rise to several mineral springs. One breaks out at the base on the southern side of Cwm Callan, south-east of Blaen Callan Farm; the water has produced a dark deposit which in 1896 was tried for umber. Another, containing sulphides and probably iron-salts, breaks out on the side of the valley 500 yards west-by-south of Blaen Callan, and enjoys some local reputation. It appears to issue from the faulted strip of Millstone Grit represented on the map, but the Grey Grits of Pen y Gaer come up to the fault only a few yards to the north and may be the source of the medicinal ingredients. A third—ferruginous and apparently hepatic—known as Ffynnon Llysieuog, breaks out at the side of a small cascade on one of the tributary streams of Nant Llysieuog. The stream also is highly ferruginous, and there is said to have been a bathing-place a little farther up. The spring or springs, which are still occasionally resorted to, issue at or a few feet below the base of the Grey Grits.

About 120 yards east of an old level on the river Haffes, a post standing in the peat in 1898 was said to mark the site of a sulphur spring. The water presumably arises from the Grey Grits, which there is reason to think crop out underneath.

CHAPTER III.

CARBONIFEROUS ROCKS.

CARBONIFEROUS LIMESTONE SERIES.

Introduction.

By A. STRAHAN.

The limestone of the region under description is readily divisible into the two groups which have been described in previous Memoirs under the names of the Main Limestone and the Lower Limestone Shales, but further subdivisions become feasible as the beds are followed westwards, and seem likely to persist. In the first place between the limestone proper and the Millstone Grit there appear some shales, which, though too thin to be shown on the map, are important economically from the fact of their containing rottenstone. These shales are immediately overlain by the quartz-conglomerate which forms the basal bed of the Millstone Grit, but great as must have been the change of conditions which led to the flooding of a tranquil area with a huge mass of gravel, we have found no evidence of unconformity, nor even of local erosion.

The Main Limestone consists in general of dark limestone above and below with a band of light-coloured oolite between, but in parts of the area a light-coloured oolite occurs at its base also. Chert occurs sparingly except in the uppermost black limestones which underlie the rottenstone beds. Thin sandstones appear at more than one horizon, and the base of the upper oolite sometimes becomes so highly charged with sand as to weather into a friable sandstone. These varieties of limestone are subject to rapid changes and are seldom sharply defined from one another, the oolitic structure being especially capricious in its occurrence. The aggregate thickness of the Main Limestone, however, remains fairly constant at between 600 and 700 feet.

The Lower Limestone Shales, which have at their base a thick encrinital limestone round much of the eastern part of the Coal Field, cease here to possess that feature, the Lower Limestone dying away at the river Neath. On the other hand, there are bands of limestone, seldom more than a foot thick, in the upper part of the shales. In Glyntawe the thickness of the Lower Limestone Shales amounts to about seventy feet. Downwards the limestone-series passes into the Grey Grits which are classed with the Old Red Sandstone, but which are at least as likely to belong to the Carboniferous system (p. 8).

Much of the limestone-outcrop is overspread by a glacial drift composed almost exclusively of Old Red detritus, and its characteristic scenery is much modified. Cefn Cil Sanws, however, is a good example of a limestone-escarpment, while both the ridge extending from Penderyn to Craig-y-Dinas and the central axis of Cribarth illustrate the effect of the arching up of so massive a rock as the oolite. The gorges, not always easy of access, present characteristic examples of river-erosion on such a rock, and especially show the tendency of rivers to find underground channels. The Sychnant, Hepste, Mellte, and Neath all disappear in parts of their courses across the limestone, while small streams innumerable are swallowed on the mountain-land, and thrown out again. The upper Byfre disappears in this manner, the Llynfell issues from a cave at Dan yr ogof near Craig-y-nôs in the Tawe valley, and the Giedd vanishes from sight at a spot called Sink y Giedd. Notwithstanding the abundance of these underground channels but few dry caves have been discovered, and from none of them have bones been obtained.

A peculiar fracture has been observed in the limestone of this part of the North Crop, and in that of Gower (Sheet 247.) In section it meanders somewhat like the sutures of an ammonite, and under the microscope can be seen to cut through the oolitic grains. Though obviously a subsequent structure due to strain, it presents no resemblance to the clean-cut divisional planes of ordinary jointing. The structure is especially conspicuous on weathered surfaces. A specimen of the ordinary dark oolite (No. 2 of Section below) which forms the lower part of the Main Limestone, and shows the 'suture-structure,' was sliced for the microscope, and is thus described by Dr. Flett:—

E. 3399. Plâs-y-gors, Ystradfellte, Brecknock. A limestone with very perfect oolitic structure, the grains being cemented partly by calcareous debris, partly by crystalline calcite. Organic fragments are very common, chiefly pieces of echinodermata and foraminifera. There are a few small patches of cherty character. A highly sinuous "sutural" fracture traverses the section, and is filled with crystalline secondary calcite.

The following table exhibits in descending order the minor subdivisions of the Carboniferous Limestone Series which can be recognised in one part or another of the map, and in the ground to the west of it.

General Section of the Carboniferous Limestone Series.

Upper Limestone Shales, 0 to about 20 feet.	Shales with rottenstone.
Main Limestone, 430 to 700 feet.	4.—Dark limestone with chert.
	3.—Light-grey oolite, a honey-combed sandstone at its base.
	2.—Dark limestone and oolite, a coral-bed near its base.
	1.—Light-grey oolite, thinning out westwards.
Lower Limestone Shales, 70 to 80 feet.	Shales with thin limestones.
	Lower Limestone, impersistent.

The Lower Limestone disappears west of the Nêdd (p. 31); the lower light-grey oolite (1) is not traceable west of the Tawe valley (p. 34); the coral-bed, full of *Lithostrotion irregulare*, near the base of

2 was first recognised on Pant Mawr west of the Nêdd (p. 32); and the sandy base of the upper light-grey oolite (3) first takes on the form of a definite sandstone-bed with characteristic honeycombed weathering on the west side of the Tawe valley (p. 36). The Upper Limestone Shales or Rottenstone-beds come in south of Pwll Byfre, between the Nêdd and the Tawe.

Cwm Tâf Fechan to Penderyn.

By W. GIBSON.

On the east side of the Tâf Fechan the Carboniferous Limestone Series can be divided into an upper mass of dark-blue limestones about 380 feet thick, passing down into a black and white oolitic compact rock about 50 feet thick, and a lower mass, the Lower Limestone Shales, which consist of grey shales with an irregular band of impure limestone at their base, the combined thickness not exceeding 80 feet. This Lower Limestone crops out to the west of Cwâr yr Ystrad, where it is pebbly and coarse-grained in the lower part and coarsely crystalline in the upper part. It is not visible south of Cwm Criban, and is evidently on the point of dying out, for at Odynau Tyle-y-bont, three-quarters of a mile south of Pontsticill station, it is represented by thin bands of nodular encrinital limestone lying in grey shales. The shales are seldom visible, but their outcrop is indicated by a narrow belt of swampy ground, caused by the issue of small springs along their junction with the Main Limestone.

The black and white oolite forms a line of low crags traceable from near Tyle-y-bont to Cwâr yr Ystrad. It has been quarried to the south-east of Pontsticill station, and east of Tyle-y-bont. At the latter locality the white oolite is overlain by a thin band of rubble set in red and grey marl, similar to that which succeeded the white oolite of the Clydach quarries.*

The oolite is more fossiliferous than usual, and from the quarry near Odynau Tyle-y-bont Mr. W. O'Connor has obtained a trilobite and fish-teeth, while a dental plate of a shark (*Sandalodus Morrisi*, Davis) has been found by Mr. D. F. Davies in the basal light oolite of Pontsticill. This form has been recorded from Oreton in Shropshire, and Black Rock near Bristol, but apparently not hitherto from South Wales. The specimen is identified by Mr. E. T. Newton.

The limestone overlying is not characterised by any distinct lithological characters, but about fifty feet up in it a thin band of a fine-grained porcellanous-looking limestone with small blebs of quartz can be traced from near the county boundary to Cwm Criban. Towards the middle of the mass a band of calcareous grit, from ten to fifteen feet thick, with a smaller one above it, can be detected *in situ* at intervals east of Pontsticill, and elsewhere can be traced by a line of loose blocks. To the east of Cwâr yr Ystrad this grit passes northward into limestone.

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* Sheet 232, and described in The Country around Abergavenny (*Mem. Geol. Survey*), p. 24.

The higher beds of limestone, which are crowded with *Productus*, have been extensively quarried for the Dowlais Ironworks to the west of Twynau-gwynion, and have been burnt for lime immediately to the north.

The junction of the limestone with the basal quartz-conglomerate of the Millstone Grit is clearly defined between Garth and the county boundary, but northwards is deeply covered by fallen blocks of the conglomerate. It appears, moreover, that the dissolving of the surface of the limestone has led to the subsidence of large masses of conglomerate. Such masses are met with some distance beyond the true outcrop of the rock, and one which lies north of Twynau-gwynion is of sufficient size almost to justify its being represented on the map as an outlier.

West of the Tâf Fechan the Lower Limestone Shales can be seen in one section only, namely, a small stream to the west of Bryn Glâs, which shows some highly fossiliferous grey shales resting immediately on the uppermost Grey Grits of the Old Red Sandstone. The Lower Limestone therefore appears to be locally absent, but its presence to the south of the swamp on Bryn Glâs is indicated by a few swallow-holes.

The base of the Main Limestone is marked by a low feature extending from Garn Pontsticill westwards to Ty'n-y-fedw, at which spot a strong spring issues near the line of what we take to be the Dowlais Fault. The limestone has been quarried in places and occasionally appears at the surface, but is more fully exposed to view in the narrow gorge of Nant y Glais. In its course southwards the gorge traverses white oolite for some distance beyond Blaen-y-glais, but further on, near Ogof Rhyd-sych, the stream falls over a cliff of dark limestone. West of the gorge the lower portions of the Main Limestone seldom show at the surface, though the presence of that rock is indicated by numerous swallow-holes. The middle portion, which is built up of platy limestones, stands out in ledges on the mountain side to the north, and is quarried to the north of Vaynor House.

The higher beds of limestone are extensively quarried on Morlais Hill. In the quarry to the north of the castle a dark limestone ninety-eight feet thick overlies a bed of grey oolite crowded with the shells of *Productus*, around which the oolite-grains are aggregated. A little to the north, the Brecon and Merthyr Railway intersects light-grey limestones thrown into gentle folds.

The upper beds of the limestone are intersected by the gorge of the Tâf Fechan between Pont Sarn and Cefn, and are much worked to the east of Cefn. Where the Dowlais Fault (p. 80) crosses the river at Pont Sarn the limestone is closely veined with calcite.

In Cwm Tâf the Main Limestone forms the rocky surface of Cefn Cil Sanws and its massive beds stand out prominently on Graig Fawr. Neither the Lower Limestone nor the shales appear at the surface but the existence of the former is inferred from the fact that there are some swallow-holes in the belt of marshy ground occupied by the shales. White oolite forms many bare rocky projections on the northern promontory of Cefn Cil Sanws, and has been burnt for lime in an old kiln a mile to the east of Grawen. The same rock gives rise to the bold crag of Graig Fach, while Graig Fawr above it is mainly made up of a close-textured, light-grey limestone with conchoidal fracture. The upper beds of blue productal limestone have been quarried near Wyrlod-ddu. Traced to the south these become a white oolite on which rests the quartz-conglomerate of the Millstone Grit. A similar limestone, in which a gentle roll over to the north can be detected, has been excavated into a gorge by the Tâf Fawr below the Cefn cemetery, and was quarried on the western bank for the dam of the Cardiff Reservoir three miles above Nant-ddu.

The total thickness of the Main Limestone in Cwm Tâf exceeds 600 feet, as compared with about 430 feet in the Tâf Fechan valley. To the west of the Taff much of the outcrop of the Lower Limestone Shales is concealed under the peaty swamp of Pant Sych Pant, and the Main Limestone is less clearly exposed than on the east side of the valley. A deep swallow-hole known as Ogof Fawr, in which the stream draining the moorland disappears, shows the white oolitic band near the base of the Main Limestone with a thin bed of shale and rubble over it. The uppermost beds also, near the junction with the Millstone Grit, are oolitic and frequently crowded with *Productus*. Swallow-holes take the surface-drainage and abound close to the margin of the Millstone Grit.

To the south of Garw-dylau also the upper part of the Main Limestone is a highly fossiliferous white oolite, standing out as small knolls similar to those met with in Yorkshire, north of the Craven faults. The knoll-like shape is particularly well marked close to the outcrop of the basal conglomerate of the Millstone Grit. Limestone on a slightly lower horizon is quarried about 300 yards to the north of the outcrop of the conglomerate. In the upper stage of the quarry a blue, well-bedded, fossiliferous limestone, oolitic in parts, rests on a black limestone which is used for road-metal; at a lower stage a dark-blue coralline limestone overlies a black limestone veined with calcite which carries a little iron sulphide.

In Gwar Mawr and Gwar Aberaman near Penderyn the higher beds are again extensively quarried. The upper portions are light-grey and frequently oolitic; the lowest beds exposed are dark-grey and in much request for road-metal and ballast. In the middle of the quarry-face two beds of a hard siliceous yellow grit ("Welsh Stone") separated by eight feet of limestone, have been used for building and in the construction of viaducts around Aberdare.

Penderyn (continued).

By A. STRAHAN.

Penderyn Foel is a ridge of limestone sharply arched up along the Neath Disturbance. The crest of the ridge for 1,000 yards west of the Foel is formed of oolite, generally light-coloured but dark in places.

Southwards from the crest this rock dips at angles of 35° to 45° under a dark limestone of earthy texture which is succeeded by the basal conglomerate of the Millstone Grit; northwards it dips in the reverse direction, but is faulted against a narrow strip of Millstone Grit, as shown in Section 1, Plate II. The anticline runs on to Craig-y-Dinas, but is there formed chiefly of the beds above the oolite. At Dinas and for nearly a mile east of it the structure is complicated by the fact that the fault mentioned above crosses the anticline obliquely; for some 1,100 yards it runs within the limestone-outcrop (Section 2, Plate II.), and when that is the case the limestone dips naturally under the Millstone Grit both to the north and south of the ridge. The uppermost beds, thin-bedded dark limestones, are quarried for road-metal at Dinas Rock. The interest of this remarkable region centres more in the display of the Neath Disturbance and of the structures and scenery due to it, than in the stratigraphy, which can be more easily worked out elsewhere. For a further account the reader is therefore referred to Chapter VI.

Outliers along the Neath Disturbance.

By T. C. CANTRILL.

The Carboniferous outlier of Bryniau Gleision includes the following series of strata in descending order:—

Bryniau Gleision.

Main Limestone, (part).	**Limestone.** **Sandstone.** **Grey crystalline oolite.**
Lower Limestone Shales.	**Shales with thin limestones.** **Lower Limestone, oolitic and sandy.**

The main outcrop of the Lower Limestone west of the waterfall at the head of the River Crawnon (Sheet 232) is much obscured, but west of the peat-flat shown on the map it appears to be severed from that of the outlier by the Grey Grits. North-east of the peat-flat it can be traced round Daren Fâch and Daren Fawr. It consists in part of oolite, which at Pen Bwlch Glasgwm contains not only lenticles of sand a few inches long but also a thin band of sandstone, as may be seen on the Roman Road. At the south-west end of the outlier the northern affluent of the Callan crosses the base of the Lower Limestone west of the Tredegar Fault, and shows yellow impure limestone passing down into impure crinoidal limestone, conglomerate, and white sandstone, the last two presumably the top of the Grey Grits.

Traces of the shales were seen in a swallow-hole by the side of the Roman Road 300 yards east of the 1,764 point at the summit of the outlier (Sheet 232), and again as a narrow strip along the north-east side of the Tredegar Fault.

The Main Limestone is best exposed in some old shallow workings and small outcrops at the north and north-west sides of the outlier. The lowest beds consist of exceptionally pure, almost white, oolite, in which partial recrystallisation has taken place; this is followed by a bed of light yellow siliceous sandstone, without pebbles, which can be traced by the aid of swallow-holes over the inner parts of the outlier. A small patch of limestone poorly exposed on the north-west side of the Roman Road is the highest bed here present, and is represented on the map (231) as an outlier supported and surrounded by the sandstone. The structure of the Bryniau Gleision outlier is further described and figured on pp. 86, 87.

The outlier of Dolygaer exhibits the following beds in descending order:—

Dolygaer.

		FT.
Millstone Grit.	Pebbly grit	
Main Limestone	Limestone—upper beds dark, bituminous, thick-bedded	about 410
	Sandstone	10
	Limestone—lowest beds light-grey oolite	about 130
Lower Limestone Shales	Shales with thin limestones	about 70
	Lower Limestone—blue limestone	

The Lower Limestone is seen overlying the Grey Grits in a brook which passes under the road 400 yards north-east of Neuadd, and appears to be thinner here than at Bryniau Gleision; the overlying shales with thin limestones weathering yellow, are exposed farther up the stream, but are still better shown in the side of the Brecon and Merthyr Railway at Dolygaer Station; they crop out west of the reservoir also, but are only feebly exposed at a spring. The Lower Limestone was not recognisable, and, in view of its westerly attenuation between this place and Bryniau Gleision, it seems likely to have died out.

The base of the Main Limestone leaves the south side of the Pen-tŵyn Fault east of Y Gaer, and the grey oolite is exposed on the hillside north of Neuadd, where it dips north-west at 25°. The same rock overlies the shales and is excellently exposed at Dolygaer Station; and about 100 yards farther up the line a band of yellow siliceous sandstone about ten feet thick crops out about 130 feet above the base of the Main Limestone. The Pen-tŵyn Fault presumably crosses the railway under the drift just beyond this sandstone, and brings down somewhat higher limestones which yield a brief exposure a few yards farther up the line. Still higher beds of limestone can be seen in the gully traversed by the Coed-hîr Fault; a little distance up the gully at an old limekiln, thick-bedded dark bituminous limestone can be seen dipping north-west at 25°, while still higher up, a massive white quartz-conglomerate, in no way differing from Millstone Grit, makes its appearance. The railway in passing from the base of the Main Limestone to the Coed-hîr Fault traverses a thickness of about 500 feet of limestone, no allowance being made for the Pen-tŵyn Fault; adding 70 feet as the approximate thickness of the Lower Limestone Shales, we arrive at a total of 570 feet. The conglomerate lies about 50 feet higher still, which gives 620 feet as the minimum thickness of the limestone series here known to exist. As the total thickness of the Carboniferous Limestone series east of Pontsticill Station, one and a half miles farther south, is only 510 feet (p. 21), it would appear that the conglomerate at Dolygaer must belong to the Millstone Grit, and not to one of the bands intercalated in the limestone, which, moreover, it does not resemble.* Traces of one of these, perhaps the ten-foot bed of Dolygaer, may be seen in swallow-holes west of the reservoir. The structure of the Dolygaer outlier is further described and figured on pp. 87-89.

Outliers along the Neath Disturbance (continued).

By W. GIBSON.

The Neath Disturbance, where it crosses the Tâf Fechan, has the character of a faulted trough, throwing down two isolated masses of limestone, the more easterly of which extends across the valley. On the west side of the valley it is possible to see that much crushed white limestone is faulted on the south against the Brownstone subdivision of the Old Red Sandstone. The limestone dips to the east and appears to run out naturally westwards, in which direction an outcrop for the Lower Limestone Shales is inferred from the presence of the topmost Grey Grits of the Old Red Sandstone. These grits are shown at the junction of Nant Car (not Nant Car Fawr) with a tributary streamlet to the north, and in the bed of Nant Car for a distance of 700 yards westwards, when a slight roll over to the west brings in the Lower Limestone and Shale, forming part of the second mass alluded to. Its extent can be judged only by the distribution of shallow swallow-holes. The limestone in the rocky bed of the stream is a dark-grey oolite with a surface beautifully polished by the action of running water.

In Nant Gwineu, 350 yards to the north of the Neath Disturbance, some large blocks of limestone are scattered along the banks of the stream and in its bed. It is difficult to suppose that they are ice-borne boulders, for no limestone occurs in the region whence the ice travelled, and though none could be found in place, they probably indicate the existence of a limestone-outlier close at hand.

Cwm Tâf to the Hepste.

By W. GIBSON.

To the east of Aber-Car in Nant Car Fawr the lower beds of the limestone are once more introduced in the trough of the Neath Disturbance. They form the bed of the stream and dip to the south-south-west, nearly at right angles to the normal dip which prevails both to the north and south of the disturbed ground. At Ynys-y-felin, on the west side of the Taff, these same beds re-appear. They still dip westwards and yet are at about the same elevation as on the east side of the valley. Evidently there must intervene either a fault with an upthrow to the west or a sharp turn up of the strata to the west of Aber-Car. At this point the limestone resumes its course along the northern edge of the Carboniferous basin, for the northernmost of the trough-faults loses itself in the thick limestone *massif* of Cader Fawr. Between the two faults north-west of Pentre-cae-lleia a white oolite full of *Productus* stands above the surface in ridges and bosses; and a dark pisolitic limestone is exposed in an old quarry to the north near a disused limekiln.

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* Geology of the Country around Abergavenny (*Mem. Geol. Survey*), p. 27.

The Lower Limestone, as seen on Pant-y-Gader south of the Hirwaun road and again to the west of the 1,240 feet level on the same road, is pebbly and impure. It makes a poor show at the surface, and, except for the exposures noted above, its presence is inferred only from the occurrence of swallow-holes. Nor can the overlying shales be seen, so that the position of the base of even the Main Limestone is uncertain. The summit of Cader Fawr consists of a white fossiliferous oolite, probably the band which we have previously noted as lying near the top of the formation. Some old quarries to the north show a dark-blue limestone with *Productus* and *Lithostrotion*.

The Hepste river exposes an impure gritty limestone (the Lower Limestone) north-east of the junction with the Hepste-fechan. At the farm of that name, the overlying shales form the banks of the river. A white oolitic limestone succeeds, and, as far as is seen, constitutes the bulk of the Main Limestone on the western slopes of Cader Fawr and Cefn Cadlan. In places, as near the Hirwaun road a quarter of a mile east of Tir Mawr, it is crowded with the shells of *Productus* which weather out and lie loose on the surface of the ground. Near the summit of Cefn Cadlan a small inlier of blue limestone appears from beneath the Millstone Grit on the crest of a small anticline; it was formerly burnt for lime near Coedcae-du.

The Main Limestone covers a considerable expanse on Mynydd y Garn, but only emerges from under a mantle of drift in the form of isolated bosses and detached ridges. The rock immediately underlying the Millstone Grit is of a blue colour, the white oolite which formed the topmost bed further east appearing some distance below. Beneath this on the north-western slopes of Gwaen Cefn-y-Gareg, there occurs a black variety of limestone with thin partings of shale.

The bed of the Hepste from Hepste-fechan down to Hepste Bridge is entirely in limestone and in summer months remains dry for the last mile of the distance. The fissure, however, by which the river enters cannot accommodate the winter-flow, and the open-air channel is then occupied. The number of strong springs which issue from the eastern banks shows that the surface-water sinking into the swallow-holes on Cefn Esgair Carnau, Cader Fawr and Cefn Cadlan is not entirely lost to the Hepste.

The Hepste (continued).

By A. STRAHAN.

Lower down where the channel of the Hepste lies in the basal pebbly grit of the Millstone Grit the water again disappears. Two open holes half a mile above the Ysgwd yr Eira yield the explanation, for in the upper one limestone can be seen underlying the grit at a depth of ten feet below the river-bed, while in the other the water can be heard in its underground course. Seventy yards below the upper hole the river re-emerges into its open-air channel. Two hundred yards above the junction with the Mellte the limestone comes up again into the bed for a few yards on the upthrow side of the Clyn-gwyn Fault (p. 42), but the water keeps above ground.

The Hepste (continued) and the Mellte.

By T. C. CANTRILL.

West of the Tâf Fawr Valley a light-grey oolite, very sandy and charged with numerous small pea-sized pebbles of white and pink vein-quartz, forms the base of the Lower Limestone, and a thin yellow sandstone appears near the top. There are many exposures of these rocks on Cefn Esgair Carnau.

West of the Hepste the outcrop of the Lower Limestone Shales is greatly obscured by drift and peat. A pebbly and gritty limestone, which projects through the drift west of the mouth of Nant y Cwrier, marks the position of the Lower Limestone, and some strong but intermittent springs farther to the north-west, which give rise to Nant Llwch, presumably issue from its base.

North-east of this point some blocks of dark oolite occur on a knoll about 200 yards south-west of a sheepfold (Ffald Powell) at the mouth of a small affluent of the Hepste, and a strong spring issues at the south-east corner of the fold; while 400 yards farther up, the bed of this side-stream shows sandy limestone lying nearly flat, and containing numerous specimens of *Bellerophon decussatus* (Flem.).

The brook north of Pen-fathor-uchaf shows, under the drift, in descending order, brown earthy limestone, dark oolite and fine-grained limestone, and rotten earthy limestone, overlying two or three feet of Grey Grits with the Brownstones below them (p. 16). On the side of the Dringarth Valley, about 700 yards south-west of Pen-fathor-uchaf, an old quarry in the Lower Limestone shows some few feet of grey oolite; and dark and pebbly limestone, overlying a few feet of the Grey Grits, crops out in a wooded bank bordering the alluvium 300 yards north-east of Mellte Castle.

The Lower Limestone Shales between the Hepste and the Dringarth are exposed only in Nant Hepste-fechan; they consist of black shales with thin bands of fossiliferous limestone. The base of the Shales crosses Nant Llwch presumably at a powerful spring. Traces of shale occur on the valley-side 200 yards south of Pen-fathor-uchaf.

The Main Limestone on Waen Dywarch and Mynydd y Garn is largely obscured by Old Red drift, through which, however, it projects in a number of picturesque knolls and patches. The base forms a bold feature coinciding with the upper limit of enclosure along the eastern side of the Dringarth Valley, a line along which several springs are thrown out. The sequence of the lower part of the Main Limestone in descending order is as follows :—

General Section, Waen Dywarch.

Main Limestone (lower part).	Light-grey oolite (Glog Lâs and Twyn Croes Gwallter).
	Dark limestone and oolite.
	Light-grey oolite, a few feet; the base impure and sandy.

In some part of the series, presumably at the base of the upper light oolite, there seems to be a band of white quartz-pebbly grit, numerous blocks of this material occurring here and there on the limestone-outcrop. The dark limestone and oolite have been burnt for lime at some quarries above Pen-fathor-uchaf.

The Mellte (continued) and the Neath.

By A. STRAHAN.

The base of the Limestone Series crosses the Dringarth * just above Mellte Castle, where may be seen the section mentioned on p. 28. Thin-bedded shaly and impure limestones crop out at intervals in the river-bed for 600 yards southwards, all no doubt belonging to the Lower Limestone Shales. These, dipping southwards, pass under dark and even black limestones, which form the river-cliff opposite Ystradfellte. Leaving the river-bed and mounting the slopes, either eastwards by Gareg-fawr or southwards towards Gwaen Hepste, we pass over a thick mass of grey oolite, frequently showing itself on the hillside, and reach a narrow zone of dark limestone with black chert in seams and nodules. Directly upon this rests the basal conglomerate of the Millstone Grit, a fact which can be verified in many places, amongst others in a cave 300 yards north-east of Carn yr Arian, and again 300 to 600 yards south of Cwm-porth farmhouse.

The phenomena attendant upon the solvent action of surface-water on limestone are admirably displayed. A strong stream, peaty and muddy after rain and fed presumably by the swallow-holes on the limestone-outcrop further north, issues near Gareg-fawr. Another bursts up by the side of the river south of Cwm Porth, where the limestone is faulted against Millstone Grit. Porth yr Ogof furnishes an excellent example of the tendency of rivers to find underground channels in limestone. The Mellte formerly flowed over a massive grey oolite in a channel which is still obvious, but it touched a dark bituminous limestone beneath, in which bedding-planes are well-developed. Solution proceeded rapidly in the dark rock, and a low but wide cave was formed, the massive oolite remaining intact as a roof. One hundred and eighty yards lower down the roof has fallen in and gives egress from the cave, but the river itself issues at a distance of 250 yards from the entrance. Two copious springs break out from the river-bank, just above the entrance of the cave.

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* The Dringarth and Llia after their union are known as the Mellte.

An outlier of Millstone Grit west of Ystradfellte gives a fine view on its west side of the basal pebbly grit resting upon black limestone with chert. South of the outlier a fine-grained hard grit separates the black limestone from the oolite below, but either through impersistence or lack of exposure, has not been seen elsewhere.

The next valley, that of the upper Neath, repeats the phenomena described above. The zone of black limestone is traceable with ease along a somewhat labyrinthine outcrop, and may be examined in detail in the ravine. Pwll-du is an old issue from black limestone, which, however, the water has abandoned for an opening in the river-bed. The bank above is capped by a small patch of Millstone Grit, and the west bank opposite shows upwards of 60 feet of grit thrown down by a fault, which runs under the bed of the river for about 300 yards. Following the bed to a bend, where it leaves the fault, we find the following section :—

In the Neath River two-thirds of a mile south of Berth-lwyd.

	FT.
Millstone Grit, quartz-conglomerate	
Carboniferous Limestone :—	
Black limestone	50
Clay with hard siliceo-calcareous concretions	10
Soft yellow sandstone, very irregular, 1 ft. to	30
Clay, impersistent	1
Sandstone as above	2
Black oolitic limestone	20
Clay	10
Sandstone	4
Limestone.	

A small fault, with a downthrow east, enters the channel 200 yards above the bend referred to and keeps in it for 200 yards. The stream then runs over massive oolite with the lowest clay-bed in the east bank for a further 600 yards. There it once more falls into the line of fault, and follows it for 300 yards to a point nearly due west of Berth-lwyd.

Pwll y Rhyd gives on a small scale a repetition of the Porth-yr-Ogof. The oolite bridges the river for about forty yards, but the river in this case disappears in a deep chasm, along some strong joints ranging W. 5° N.

The Mellte and the Neath (continued).

By T. C. CANTRILL.

Where the Lower Limestone crosses the Dringarth near Castell Côch, a shoal 150 yards east of the Castell shows in descending order:—

In the Dringarth.

		FT.
Lower Limestone (part).	Grey calcareous sandstone	2 to 3
	Limestone looking like a breccia	1
	Dark oolite, seen for	2

The grey calcareous sandstone has been sliced and examined under the microscope, and is thus described by Dr. Flett:—

E. 3398. Shoal in River Dringarth, 150 yards north-east of Castell Côch, Ystradfellte, Brecknock.

A massive grey calcareous sandstone, with rounded grains of quartz averaging ·3 to ·5 mm. in diameter, enclosed in a calcareous cement. There are a few fragments of tourmaline, felspar, and iron oxides, and a fair amount of chlorite is mixed with the calcite. The cementing material is crystalline and has often a uniform cleavage and simultaneous extinction over a considerable area.

The limestone has the appearance of having been broken into angular fragments and subsequently re-cemented. A similar appearance was remarked near Garn Caws * in Sheet 232.

The occurrence here of a band of sandstone in the Lower Limestone is to be noted. A lane, fifty yards north-east of Nant-y-Wenynen on the west side of the valley, shows dark limestone (the Lower Limestone) overlying brown grit, which may be either the same as that seen in the river, or the Grey Grits. Dark oolite can be traced along the valley side for some few yards to the north-east, but is soon lost under the drift. The shales are cut into by the brook a few yards north of Nant-y-Wenynen, and are exposed also in the roadside between the Dringarth and the ruins of Castell Côch, the beds rolling in dip.

The base of the Lower Limestone where it crosses the Llia a few yards below Aber-Llia Farm again shows a sandy character; and it is again seen under drift by the roadside 200 yards north-west of the farm. The overlying shales are exposed in a gateway by the roadside seventy yards north-west of the farm. At Plâs-y-gors the Lower Limestone with traces of shale is poorly exposed, but in the brook which issues from a swamp a few yards west of Maen Madoc (p. 17) it is twenty feet thick and is both sandy and pebbly, characters which link it closely on to the underlying Grey Grits. This is the most westerly exposure known of the Lower Limestone.

The basement bed of the Main Limestone between the Dringarth and the Nêdd is much obscured by drift, and its position is uncertain except for a short distance north-east of Blaen-Nêdd-isaf, where it forms a good feature the foot of which is followed by the Sarn Helen. The succession appears to be identical with that of Waen Dywarch (p. 29). The upper light oolite, which is usually rich in *Productus*, is easily traced, and stands out in bold scarped knolls. The occurrence of numerous blocks of white quartz-grit and conglomerate suggests that bands of this material occur interbedded in the limestone; but none has been seen in place.

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* The Geology of the Country around Abergavenny, pp. 27–28 (*Mem. Geol. Surv.*), 1900.

The Neath to the Tawe.

By T. C. CANTRILL.

West of the river Nêdd the Lower Limestone disappears, presumably thinning out or passing into shales. The shales are shown occasionally in the banks of the river between Nant y Môch and Coed-y-gareg, where the highest beds were once tried for rottenstone. Nant y Môch well shows the passage of the shales into the Main Limestone. The former with thin bands of dark limestone, which are specially numerous at the top and are all less than a foot thick, are succeeded by a persistent band of light oolite several feet thick, which serves as the base of the Main Limestone. Above this follows thick-bedded dark limestone containing traces of a shaly and rubbly bed near the bottom. Successively higher beds of dark limestone come in as we ascend the stream; but at 250 yards from its mouth, and about forty yards below a waterfall, a fault with upthrow west brings up the shales again. About 250 yards still farther up stream the base of the Main Limestone comes in again and the whole section is repeated.

On the desolate moorland of Pant Mawr the Main Limestone presents much the same detail except that an upper series of shales comes in at its top south of Pwll Byfre. This series which corresponds to the Upper Limestone Shales of old authors, contains one or two bands of dark limestone which are much sought for in their weathered condition as rottenstone. The complete sequence is as follows:—

West of the Nêdd.

Millstone Grit.	Pebbly grit and conglomerate.
Upper Limestone Shales.	Dark shales with limestones.
Main Limestone.	Dark limestone with chert.
	Light oolite; a sandstone bed at its base.
	Dark limestone and oolite.
	Light oolite, several feet.
Lower Limestone Shales.	

The basal light oolite which steadily diminishes in thickness as followed westwards across the map is still to be detected in Nant y Môch. In the dark limestone and oolite of the general section on p. 20, a coral-band full of *Lithostrotion irregulare* makes its first appearance north-west of Coed-y-gareg. Thence it may be traced at intervals in a north-westerly direction, keeping at a level of about eighty feet above the base of the Main Limestone. Among other varieties there may be noticed some dark fine-grained limestones ('china-stone') two feet thick and some bands composed almost wholly of shells of small brachiopods and others, while the top of this subdivision (No. 2 of the section on p. 20) of the Main Limestone frequently becomes sandy. The upper light oolite, No. 3, contains numerous specimens of *Productus*, and can be easily traced across Pant Mawr, though its upper limit is not so definite as its base. The overlying dark limestone with chert-nodules, No. 4, is often concealed by Millstone Grit debris. It is frequently sandy, as, for instance, on the eastern side of Sand Hill, and may even contain white grits and conglomerates, for numerous blocks of that material are noticeable all over the outcrop. It is equally likely, however, that these are relics of the once superjacent Millstone Grit. The only place where such a rock assumes the appearance of being *in situ* is in a little brook flowing eastwards and entering the Nêdd at one-third of a mile above Coed-y-gareg. The exposure is 400 yards up the brook, and shows yellow quartz-conglomerate to a thickness of four feet. The rock is jointed and crumbling, and seems to have a high dip, but whether it is interbedded and has been brought to this fractured condition by the Pant Mawr Fault, or whether it is a mass of Millstone Grit slowly let down from a position some hundreds of feet above by dissolution of the limestone and fractured in its descent must be left an open question.

North-west of Sand Hill a broad tongue of drift and debris extends from the Old Red Sandstone southwards over the limestone and beyond it. The Lower Limestone can no longer be traced, but the shales are exposed in a brook at a point shown on the map. Carn yr Onen and the ground to the south-west exhibit numerous sections of the Main Limestone; the basal light oolite gradually thins westwards, but can still be detected 300 yards north-west of Pwll Byfre, and is possibly present in Cwm Byfre (p. 34). The coral-bed, last seen to the south of Nant y Môch, is again exposed at an old quarry * 350 yards west of Pwll Byfre, with a thickness of six feet. It lies about sixty feet above the base of the Main Limestone, and can be traced at intervals to Nant Byfre. The base of the upper light oolite (No. 3 of section on p. 20) becomes so markedly sandy as to pass when decalcified into a soft grey or yellow sandstone. At the base of the dark limestone with chert, No. 4, there are traces of a rubbly and shaly bed; and this is succeeded by some grey sandy oolite with *Productus*, followed by the dark limestone with chert-concretions. At the top of this are a few feet of grey limestone with large grains of quartz and films of sand, appearing like threads on weathered surfaces.

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* This quarry was opened many years ago, but presumably subsequent to the Ordnance Survey of 1832, and the limestone was conveyed by a horse-tram-line still traceable round the sides of the Tawyneu and Crai valleys as far as Nant Gihirych, where it joined a still older line of tram—marked on the map of 1832—running from the quarries at Penwyllt southwards to the iron furnaces near Ystradgynlais, and northwards to a wharf on the Usk at Devynock.

The most important change, however, is the setting-in of the Upper Limestone Shales, a band of dark shales with thin seams of black limestone immediately below the Millstone Grit. These limestones become decalcified at their outcrop, and leave an impalpably fine residue of *rottenstone*, which has been dug at intervals for many miles westwards. The trials commence on the parish boundary south of the summit of Carn yr Onen, but neither shales nor rottenstone seem to have been found. In the next trial, south of Pwll Byfre, some shale has been thrown out, and two-thirds of a mile farther south-west a small quantity of rottenstone was found. Thence onwards the old workings are almost continuous, and were being re-opened in places in 1898.

West of Carn yr Onen the base of the Main Limestone forms a bold feature along the south side of the Byfre Valley; and is specially well-marked at and west of Twyn Disgwylfa. The shales can be seen at one or two points west of Pwll Byfre, and their position can be inferred as far as some grassy fields west of Pant-y-ffynnon at Penwyllt, where they are brought to the surface along the crest of the Cribarth anticline. Dipping thence rapidly to the north-west they cross Nant Byfre south-east of Capel Callwen, where the following measurements were made:—

Cwm Byfre, south-east of Capel Callwen.

		FT.	IN.
Main Limestone (part). 98 FT. 2 IN.	Dark limestone, thick-bedded		
	Dark oolite, thick-bedded	36	0
	Dark limestone with *Lithostrotion irregulare* (Coral Bed).	6	0
	Dark limestone, thick-bedded	37	0
	Black shale parting		3
	Dark limestone in two beds	1	8
	Nodular fine grey limestone with specks of iron pyrites	1	0
	Flaggy fine grey limestone	3	0
	White crystalline oolite		3
	Thin-bedded limestones and crystalline oolite at a waterslide	6	0
	Dark fine-grained earthy limestone	2	0
	Dark shaly micaceous limestone	2	0
	Hard black shale	1	6
	Dark fine-grained earthy limestone	1	6
Lower Limestone Shales. 74 FT. 3 IN.	Black shale with thin dark limestones more frequent towards base, estimated at	50	0
	Dark massive limestone	8	0
	Dark limestone, very fine-grained	3	0
	Black shale and limestones	12	0
	Black limestone	1	3
Old Red Sandstone, Grey Grits			
		172	5

There being a perfect alternating passage from the Main Limestone down into the shales, there is some doubt where to draw the line between them. It is possible that the crystalline oolite, six feet thick, may represent the basal oolite of the districts further east, but it is not known to occur west of this point. The Coral Bed is a well-marked band full of *Lithostrotion irregulare*, as determined by Mr. E. T. Newton.

The Main Limestone at Penwyllt has long been quarried and burnt. Kilns were in operation in 1898 close to the station; and there is a quarry in the dark limestone with chert a few yards north of the Silica Brick Works. The lowest limestones also were being worked half a mile west of Pwll Byfre.

A small quarry 150 yards north-west of Penwyllt Inn shows a grit-band between the dark limestone with chert and the light oolite, the descending sequence being as follows:—

Near Penwyllt Inn.

	FT.	IN.
Dark-grey sandy oolite, with threads of sand	5	0
Grit, yellowish-grey, without pebbles	2	6
Grey sandy oolite, with *Productus*	24	0
Oolitic rubbly limestone	9	0
Light-grey oolite, seen for	2	0
	42	6

The surface of the limestone on which the grit rests is pitted, and the grit in filling the depressions has acquired a mammillated form. Above the highest rock here seen lies the thick mass of dark limestone with chert formerly wrought in a large quarry a few yards to the south-west.

The upper, and now the only, light oolite is exposed in the new road leading from Penwyllt Station to the Tawe. Along the north-western limit of the Penwyllt anticline it becomes somewhat indefinite, and seems to be partly replaced by whitish amorphous limestone.

The Tawe (continued) and to the west of it.

By A. STRAHAN.

Rottenstones have been dug along the top of the limestone on the east side of the river south of Penwyllt station. The excavations, when carried below the few feet depth to which weathering has extended, show a band of limestone about one foot thick imbedded in black shale, directly upon which rests the basal conglomerate of the Millstone Grit. The limestone is dark and impure, and when decalcified, as happens at the outcrop, leaves a soft porous residue of rottenstone free from grit. It contains many fossils, among which the following have been identified by Dr. Kitchin:—Crinoid ossicles, *Athyris*, *Chonetes laguessiana*, *Productus semireticulatus*, *Euomphalus*. The outcrop is terminated by the Henrhyd Fault, the position of which is indicated by a strong spring and an exposure of limestone 150 yards south-south-east of the Vicarage.

On the west side of the river, the rottenstones have been unsuccessfully looked for along the south-east side of Cribarth, but have been dug, wherever the great talus of Millstone Grit blocks has allowed, on the north-west side. The limits of the northern part of an inlier of limestone are accurately defined by the line of old holes.

The bold central anticline of Cribarth brings all the upper part of the Carboniferous Limestone within view, and enables us to see that the uppermost beds (not including the Rottenstone Series) are subject to much variation. On the south-eastern side there are cherty beds, grey limestones traversed by irregular films of dolomite, and smooth-textured black limestones, but the rock generally in evidence is a dark oolite; on the north-western side the rock next below the Rottenstone is a black limestone with bands and nodules of black chert, and rich in *Productus*, which matches the limestone of the Ystradfellte neighbourhood. Between these two outcrops, the underlying light-coloured oolite bulges up in a narrow steep-sided arch. It has been quarried on a large scale for an old blast-furnace in the valley below, and in one quarry a quartz-grit has been touched beneath it. The same quarry shows two small north and south veins containing copper-pyrites.

There is reason to think that the limestone comes close up to the surface at Garth, a mile further to the south-west, on the crest of one of the anticlines which constitute the Cribarth Disturbance. A pebbly grit north of the house almost certainly belongs to the lower part of the Millstone Grit, and under it there is a black clay. Rottenstone is said to have been seen in an excavation in the yard, and, lastly, there is a block of limestone, which may or may not be a boulder, at the south side of the house.

West of the Tawe (continued).

By T. C. CANTRILL.

There are few exposures of the Lower Limestone Shales, but traces of them can be seen on the mountain west of Cerig Haffes, in the river Haffes north-east of the large peat-bog, Fignen Felen, and in some swallow-holes south-west of the peat-bog on Carnau Gŵys.

Though the Main Limestone shows through the drift only as knolls and patches, the same succession seems to hold good. The basal beds are impure and graduate downwards into the shales; the Coral Bed, lying about forty feet above the base, is exposed near the north-east angle of Fignen Felen, also south of Carnau Gŵys, and again in the Gŵys at the dip-arrow shown on the map. At the last locality a few feet higher in the limestone and seventy yards lower down stream some ferriferous dolomite is to be seen under the drift. The Coral Bed seems to approach the base of the limestone as its outcrop is followed westwards. The base of the light oolite becomes increasingly sandy, so as to form, when decalcified, a soft fine-grained sandstone which weathers in a characteristic pitted or honeycombed fashion. It can be traced at intervals from the Tawe Valley west of Dan-yr-ogof to a point 250 yards south-west of the intersection of the Giedd River by the parish-boundary. Here it appears as a low crag of soft white gritty sandstone, ten feet or more in thickness. South-west of Fignen Felen a thin sandstone occurs in some dark oolite with *Productus* which forms the lower part of the dark limestone with chert, but it cannot be traced for more than a few hundred yards in either direction. A similar rock crops out apparently at the same horizon 700 yards south-west of Craig-y-nôs Castle. Another band crops out in some gritty limestone 300 yards south-west of the Saithmaen on the west side of the Tawe; it appears to be on the horizon of some sandy limestone forming the top of the dark limestone with chert. The rottenstone beds have long been and were still in 1898 worked along the outcrop from the Tawe as far as the east side of Careg-lem, beyond which they are buried in drift.

A rough estimate, based on observations of dip, altitude, and breadth of outcrop, gives as the thickness of the Main Limestone east of Ystradfellte, 630 feet; at Pwll Byfre, 670 feet; east of Castell y Geifr, 630 feet; between Carnau Gŵys and Careg-lem, 740 feet; and at Careg y Dwfan near Trapp, some miles farther west (Sheet 230), 715 feet.

A small outlier of Carboniferous beds on Fan Gihirych will be found described on p. 93, in connection with the Cribarth Disturbance.

CHAPTER IV.

CARBONIFEROUS ROCKS (*continued*).

MILLSTONE GRIT.

Introduction.

By A. STRAHAN.

The threefold subdivision of the Millstone Grit which was adopted in Monmouthshire has proved convenient also in the region under description, where the following sequence occurs :—

Farewell Rock, at times a quartz-conglomerate, but in the Vale of Neath a massive sandstone. This passes down into alternations of sandstone and shale, and so into the underlying subdivision. Thickness about 150 to 200 feet.

Shales with few sandstones, but with bands full of lamellibranchs with the valves united, and with seams and nodules of clay ironstone, the whole having a Coal Measure aspect. About forty feet from their base these shales contain a band of grit averaging twelve feet in thickness, which forms a constant feature in the ravines of the Sychnant, Hepste, Mellte, Neath, and Perddyn rivers. The shales above and below this grit are dark, and contain thin seams of ironstone, or sometimes of dark fossiliferous limestone. Generally, however, the limestones have been weathered into concretionary iron-ore, and the fossils obliterated. Thickness 100 to 150 feet.

Pebbly grit, for the most part crowded with pebbles of vein-quartz, some of which range up to three inches in length. The rock is split up by extremely irregular lenticular beds of black shale, especially in the upper part, and thus tends to merge into the overlying shale sub-division. Many large drifted tree-trunks occur, and even thin coal-smuts, but the fauna, found only in the shales, is purely marine. Thickness 80 to 100 feet.

The detailed account of the outcrop will proceed, as in the othe formations, from east to west.

Dowlais to Penderyn.

By W. GIBSON.

The three subdivisions are clearly defined to the east of Dowlais, for the middle subdivision consists almost entirely of shale, and the Farewell Rock is a coarse, well-defined grit with few or no shale-partings. But west of Dowlais the shales are broken up by several thin bands of grit, while the Farewell Rock not only becomes a fine-grained sandstone indistinguishable from the rock-bands in the overlying Lower Coal Series, but includes several bands of shale similar to those in the subdivision below, so that neither its top nor its base can be accurately determined.

The lowest subdivision retains its character as a hard siliceous grit with numerous pebbles of vein-quartz, from the eastern margin of the map to Penderyn. The outcrop is clearly defined and conspicuous in the landscape. The upper portion is slightly more siliceous than the lower part; it contains, moreover, few or no pebbles and is sometimes split up by thin partings of black shale. Casts of the trunks of *Lepidodendron* are scattered over the surfaces of the bedding-planes, and are especially abundant north of Pitwellt Pond north-east of Dowlais. The thickness of this subdivision is difficult to estimate, but it probably never exceeds 100 feet and is seldom much under.

The upper beds are quarried for road-metal near Cefn and the more siliceous varieties for fire-bricks to the west of Dowlais Cemetery. Near Penderyn certain bands are remarkably pure and are important as a source of silica for the silica-works at Hirwaun. The rock chiefly in requisition is a highly siliceous fine-grained bluish grit nearly free from felspathic material.

The outcrop of the subdivision is thickly pitted with swallow-holes, which are especially numerous, deep and large on Mynydd y Glôg to the north of Hirwaun. They are most abundant on the outcrop of the lower beds of the conglomerate, but occur as far as the margin of the outcrop of the shales, beyond which they become extremely rare. A large amount of the surface-drainage is carried off underground by these holes, but the water tends to reappear at lower levels.

The shales are well exposed in Nant Morlais to the north of Dowlais. The subdivision is made up almost exclusively of black and grey sandy shale, the intercalated sandstones being thin and impersistent. A small tributary which joins the main stream at the spot where it is crossed by the Brecon and Merthyr Railway intersects some dark shales and mudstones in which lie two bands of dark earthy limestone containing *Glyphioceras* in abundance. These bands lie a few feet only below the base of the Farewell Rock, and are the highest marine bands met with in the Millstone Grit on the northern crop. South of the railway and at a slightly lower horizon the banks of the stream consist of black fissile shales, crowded with *Carbonicola acuta,* above which come dark shales containing small nodules of ironstones with *Cephalopoda.* The Carbonicola usually occurs above the other fossils recorded from these shales. Complete lists of the fauna from various localities will be found on pp. 49, 50 and in the Geology of the Country around Abergavenny (*Geol. Survey Memoir*) 1900, pp. 47, 48.

West of Dowlais the ground is covered with drift and the shales are seldom visible. They are exposed at intervals in the banks of the Taff south of the Cyfarthfa Ironworks and at a spot 600 yards north of Goitre Pond, in an old tram-line from Goitre to Morlais Castle Quarries.

On the west side of the Taff the shales are deeply gashed by the picturesque gorge of Nant Ffrwd. A thin band of black shales cropping out in the southern bank of the stream 450 yards west of its junction with the Taff, contains numerous specimens of *Lingula* and *Cephalopoda*.

South of Oen Llwyn there are few outcrops, but shales containing small nodules of ironstone form a small cliff near the parliamentary boundary in the upper part of Nant Ffrwd. Thence westward to Penderyn their existence is indicated chiefly by a belt of swampy ground, but in Nant Melyn near the south end of the reservoir the stream intersects some black shales containing nodules of ironstone, which yield *Productus* and *Cephalopoda*. The exact horizon is doubtful, but it is high up in the middle subdivision.

The shales are of little economic importance, except that their outcrop affords suitable sites for storage-reservoirs. It has been thus utilised for the Aberdare waterworks in Nant Melyn.

The Farewell Rock north of Dowlais Top Station is a strong siliceous grit, pebbly in places, and has been quarried near Pen-y-garnddu. The outcrop is scarcely traceable for some distance westward, being concealed either under drift or the town of Dowlais. The same indefiniteness owing to the cover of drift or grassy moorland characterises it westward of the Taff. In Nant Hir and Nant Melyn, about three miles north of Aberdare, the rock is split up by subordinate bands of shale. The upper part, as seen in the banks of the Cynon river between the Gamlyn viaduct and Hirwaun, consists of thin flags and sandy shales which poorly represent the hard siliceous grit near Dowlais. That these flags should be included in the Millstone Grit, and not in the Lower Coal Series, is shown by the fact that the Cnapiog Seam crops out 300 yards to the south of, and therefore above them.

North of Hirwaun the outcrops of the subdivisions of the Millstone Grit are wholly conjectural, thick deposits of drift completely concealing the solid geology.

At Penderyn the Neath Disturbance takes the form of a sharp anticline, the crops on the south side of the uplift being repeated on the north. The quartz-conglomerate, arching over the anticline, covers considerable areas on Cefn Cadlan and Gwaen Cefn-y-gareg. It presents the same characters as in the ground to the south and east; and that it lies immediately upon the limestone can be seen in several places, especially in a cavern on the edge of the escarpment west of Gwaenydd Hepste. Near Tir-y-duwinydd on the west side of the Hepste, a little north of Hepste Bridge, a natural archway has been formed by a stream having dissolved the limestone but left the overlying conglomerate as a roof. Considerable uncertainty exists as to the rock beneath the drift filling Cwm Cadlan. A few fragments of shale thrown out from a well south of Coedcae-du constitute the only evidence, and as thin bands of shale occur in the basal subdivision, they do not necessarily imply the presence of the middle shales. On the contrary, the fact that the basal conglomerate to the north dips at a gentle angle in close agreement with the slope of the ground, makes it far more probable that that rock underlies the drift of Cwm Cadlan. There is certainly no evidence to warrant the local belief in the existence of Coal-measures.

Penderyn, Glyn Neath, and Ystradfellte.

By A. STRAHAN.

The ravine known as Sychryd gives a long exposure of the shales of the middle part of the Millstone Grit. The Farewell Rock comes on just above the railway, and is well laid open in the eastern approach to the tunnel. Eastwards, after keeping level for about 1,000 yards, it plunges down suddenly to the south-south-east under the Coal-measures of Cwm Wyrfa; westwards it descends gently to the Neath near Pont Whalby, where it becomes involved in the Neath disturbance (p. 92). The Sychryd, after a smooth course over shale, meets its first waterfall at a point due east of Pen-cae-drain. The fall is caused by a sandstone, twelve feet thick, which lies a few yards above the main mass of the basal conglomerate, and which can be traced through many miles of the ravines of the Neath and its tributaries. From the fall this band can be followed through the top of Coed-y-Ffyrnau round to the west side of Pen-cae-drain in the one direction, and at its proper distance above the limestone of Dinas in the other; above it, in a ravine running eastwards parallel to the outcrop, there are exposed black fossiliferous shales with ironstone-nodules. The Sychryd, below the fall, crosses shale for 200 yards and then traverses the basal quartz-conglomerate. The quartz-conglomerate forms a conspicuous part of the anticlinal ridge which runs from Dinas Rock to Penderyn Foel. Being an almost purely siliceous rock, it is in great request for the making of Dinas fire-bricks, and has been mined for that purpose under the gravel-flat 300 yards north-east of Ynyscarnbwll and quarried in Coed-y-Ffyrnau. The quarry gives an admirable view not only of alternations of quartz-conglomerates, grits and shales, but of the sharp curve-up by which these strata pass from a dip of 15° to verticality on the flanks of the anticline.

A fault throwing Millstone Grit against limestone runs along the bed of the river just below the quarry, but passes into the limestone abreast of the quarry. The structure will be described in the chapter dealing with disturbances, and it is mentioned only to explain the crushed condition of the quartz-conglomerate at this spot. For the rest of its outcrop to Penderyn the conglomerate, though highly tilted, rests naturally upon the limestone.

On Penderyn Foel the fault becomes a downthrow north, and introduces a narrow strip of Millstone Grit on the north side of the anticline. The wedge of jumbled-up conglomerate, grit and shale thus thrown in has been mined in all directions for silica, and now lies in utter confusion, but it is possible to see that it includes more than the basal conglomerate, that it dips on the whole southward towards the limestone of the foel, and lastly, that the fault-face itself forms the wall of some of the open-air workings. Towards the north on the other hand, it rests naturally upon limestone which also dips south, but which immediately arches over and plunges at 20° to 35° under Millstone Grit again. Crossing this outcrop in a north-west direction we find the sequence fairly shown; at least two thick beds of pebbly grit are in evidence, with a band of shale between, while the upper grit is overlain by shale and a thin sandstone, no doubt the twelve-foot band to which allusion has already been made.

Turning now westwards, we can follow the generally conspicuous features made by these rocks to the Mellte ravine, getting in the east bank a nearly uninterrupted view from a soft sandstone and shale belonging to the upper division of the Millstone Grit, through the shales of the middle part with the twelve-foot sandstone, down to the base of the pebbly grit. The last-named, assuming a high dip as it nears the anticline, runs along the river to the entrance to the Powder Mills, where the grit forms the north bank and the limestone the south bank of the river-bed. The north cliff of the ravine along this same tract is formed by the upper part of the Millstone Grit, a sandstone which, though generally massive as in the hill above Plas-y-dinas and the ravine of Llwyn-y-collen, is in places much split up by shale.

In following the Mellte and Hepste upwards, we meet frequent repetitions of these rocks. A small fault south-east of Carn-y-crochan brings up the top of the pebbly grit, and of course the twelve-foot sandstone above it, into the bottom of the valley; 400 yards further up both are faulted out of sight again, but 300 yards further up again, near the mouth of the Hepste, sandstone reappears in the bed of the river, and continues in it for 700 yards. Steep cliffs of shale hem in the river on either side, with a precipitous brow of the upper sandstone.

At this point we may turn up the Hepste. Passing over shale at the entrance to the ravine, we reach the Clyn-gwyn Fault at 200 yards. The fault is an upthrow east of sufficient magnitude to bring the top of the limestone into the bed of the river, that is a throw equal to the thickness of the pebbly grit in addition to a part of the shales above. It is visible in the south bank, and higher up on the same side the top of the pebbly grit and the twelve-foot sandstone, with about twenty-five feet of shale between them, are readily identified. A second fault, with a downthrow east, crosses the ravine 250 yards above the Clyn-gwyn Fault, and can be detected in the outcrop of the twelve-foot sandstone on either side. Seventy yards above this we reach the noted waterfall known as Ysgwd yr Eira. A lenticular bed of shale from three to eight feet thick interstratified in the pebbly grit is the cause of the fall; it has crumbled away so much in excess of the rock above and below it that the path is carried along its outcrop and behind the falling water. The face of the fall shows eighteen feet of sandstone above the shale and ten feet below it. A third fault with a downthrow west of twenty feet crosses seventy yards above the fall; this also is determinable in the outcrops at the top of the pebbly grit, especially on the south side where the fracture is visible. On the north side a small ravine close to the line of fault shows the shales between the pebbly grit and the twelve-foot sandstone; they contain a band six inches thick of calcareous ironstone full of fossils (p. 49), a somewhat unusual circumstance, for such beds have nearly always passed into the condition of concretionary iron-oxide. Hence upwards the ravine of the Hepste runs in the pebbly grit. The limestone, as noted on p. 28, lies a few feet below the bed of the river, while the brow of the ravine is formed by the top of the pebbly grit, the depth of the ravine being about 100 feet. Lastly the twelve-foot sandstone may be traced across the mountain on either side of the river; on the north side where it approaches a loop of the river east of Cilhepste-coed the shales below it again yield fossils.

We may now resume the ascent of the Mellte. The Clyn-gwyn Fault receives its name from a series of beautiful falls and cascades west of Cilhepste-coed, of which it is the direct cause, for, acting in conjunction with the next fault east of it, it brings up a wedge of the basal grit about 200 yards broad into the bed of the river, and thus makes a natural dam. Here again the twelve-foot sandstone can be easily recognised in the precipitous banks on either side of the river, with about twenty-five feet of shale between it and the pebbly grit. Above these faults the top of the pebbly grit is just below the river-bottom and the twelve-foot sandstone runs along the side of the ravine, but about 200 yards farther on the pebbly grit emerges and runs to the foot of the upper Clyn-gwyn waterfall. This fall again is caused directly by a fault. The water above the fall flows over the top bed of the pebbly grit; the fault throws that rock down west thirty feet, and the water, leaping down the face of the fault, regains the same bedding-plane. Finally we reach the limestone at a point 300 yards north of Hendre-bolon; it is brought up by a fault, the course of which is clear enough northwards, but which is concealed by drift in the banks of the river. The pebbly grit, however, whether as outliers or long faulted strips, extends a mile or two beyond this point on the watersheds. At its margin the rock has generally sagged down a little through the perishing of the limestone-support, and it is interesting to see that the sagging took place before the glaciation, which is beautifully shown on many of these cornices.

The upper Neath, as we may conveniently call this part of the river, joins the Neath at Pont-nêdd-fychan. It issues by a gorge in a massive rock which forms the upper part of the Millstone Grit, but 150 yards higher up the valley opens out in the underlying shales. The twelve-foot sandstone crops up at Pont-nêdd-fychan Mill, and can be traced thence along the east bank for 300 yards. On the west bank it is lost in a landslip for 550 yards, but then can be followed continuously to the Gwladys Waterfall, of which it is the cause, and then on both sides of the Neath for half a mile. Through all this distance the river runs in a gorge in the upper part of the pebbly grit. That rock has been worked for silica-bricks by many levels on both sides of the valley, and a large open excavation on the east side, made for the same purpose, shows that it contains in its upper part about twenty-five feet of black shale and irregular gannister-sandstone with an impersistent coal-smut. A fault with a downthrow west which follows the valley can be seen in the river-bed to the north-west and south-west of the quarry. Above its junction with the Perddyn the Neath runs in a gorge of the pebbly grit with bands of shale in which the twelve-foot sandstone is constantly in evidence. A fault with a downthrow west of ten feet crosses the channel 750 yards above the junction, and runs up Nant Llechau. Barytes occurs as a vein-stuff, and a level driven in it on the west bank is said to have been made in search of silver, or presumably argentiferous galena. A small side-stream on the same side and 150 yards farther up exposes dark shale with septaria and a thin black limestone containing *Productus semireticulatus* in abundance with other fossils. The band occurs at the same horizon as that noted in the Hepste (p. 42). The remainder of the valley up to the limestone shows the pebbly grit gradually rising, and forming bare rock-slopes on the west side, but deeply covered with Boulder Clay on the east side. There are many small faults; one with a downthrow east brings the twelve-foot sandstone down to the river-bed 600 yards south of Pen-y-bont; rising thence north, that rock is thrown down again to the same level by a fault of twenty feet visible 100 yards below Pen-y-bont; another fault, with a downthrow west, crosses 250 yards above Pen-y-bont; lastly we have the fault alluded to on p. 30, as running along the bed of the river at Pwll-du, and throwing in the Millstone Grit on the west bank. The sagged and glaciated cornices of grit which follow the west side of the valley for a mile or more are noteworthy.

The Perddyn in the Gwladys waterfall, 350 yards above its mouth, leaps clear down the ledge formed by the twelve-foot sandstone. The sandstone is about eight feet thick, and above it there lie upwards of 100 feet of shale in an inaccessible position, but yielding in a talus, 350 yards above the fall, blocks abounding in *Cephalopoda*. The ravine is bordered by the upper rock of the Millstone Grit, but at a point 750 yards above the fall (measured round the bends of the valley), that rock is thrown down to the level of the channel by a north and south fault. The fault, which is a downthrow west of about fifty feet, can be detected in the river and in small chasms up either side of the ravine. By bringing hard grit into juxtaposition with shale it gives rise to the picturesque Einon-gam waterfall. Above the fall the river runs over blocky sandstone irregularly bedded with shale; the brow of the fall is formed by a blocky sandstone about ten feet thick, and the chasm below shows about forty feet of alternations of shale and sandstone resting on shale. Thence upwards, the valley, though much cumbered with drift, yields an occasional view of this same upper or Farewell Rock and of the Coal Measure shales which rest upon it.

The Vale of Neath collects the waters of the various ravines described above. It traverses the outcrop of the Millstone Grit for nearly three miles, and enters the Coal Measures at Glyn Neath Station. It follows the line of the Neath Disturbance, however, and although the detailed structure is concealed, the main fact is obvious, that the Farewell Rock of the south side would, if prolonged, pass far above the Millstone Grit of the north side. The difference in level is due to the complicated folding which here constitutes the Neath Disturbance, and amounts to about 600 feet.

The Farewell Rock is well exposed in the ravines of Nant y gwynau and Nant Llwyn-y-gwin, but is more accessible in the gorge which gives access to Nant Gwer-elech, and along the railway to Glyn Neath Station. It is generally a massive grit, but is irregularly and locally split up by shales. At Pont Whalby the grit rolls over in a sharp anticline, and plunges under the river with a dip to the N.N.W. of 40° to 50°, but it re-emerges at Glyn Neath with a south-easterly dip. Between Glyn Neath and Pont-nêdd-fychan it is poorly exposed, probably through the effects of a crush-plane which crosses the Neath 120 yards below the Angel Inn and runs thence along the hillside to Glyn Neath. A sandstone which crosses the railway 550 yards north-east of the road-bridge is worked for silica-bricks; it lies not far below the base of the upper rocky member of the Millstone Grit. The pebbly grit just comes into sight in the river bank 250 yards west of the junction of the Mellte and Neath. Shale with ironstone and containing *Cephalopoda* abundantly occurs in the ravine of Nant y gwynau, fifty yards south of the railway.

West of the Neath, and the Tawe Valley.

By A. STRAHAN.

The broad mountain tract north of the Perddyn calls for no special remark. Much of it is deeply buried under Boulder Clay, but the pebbly grit stands up well and gives many well-glaciated rock-floors. The twelve-foot sandstone also can be picked out at intervals along the course shown on the map. For the remainder, the shales and part of the Farewell Rock are well laid open in Nant Llech-pellaf and its northern tributary Nant Cwm-byddar. Nant Llech crosses the Henrhyd Fault at the waterfall of that name. The fall is due to the fact that soft Coal Measure shales are thrown face to face with a massive grit forming the lower part of the Farewell Rock. The fault can be detected in both banks of the ravine. It may be noticed that the fall has cut its face back about 30 or 40 yards from the fault-face, and that this erosion has probably been accomplished wholly in post-glacial times. The face of the fall shows about 50 feet of sandstone resting on shale exposed to 14 feet.

A wilderness of loose blocks with an occasional scarp of well-glaciated rock-in-place marks the outcrop of the pebbly grit south of Penwyllt. A few yards above and separated by a peaty strip, doubtless underlain by shale, there crops out a sandstone about 15 feet thick, which is perhaps the twelve-foot sandstone of the Neath and Mellte ravines, but Nant-y-ffin shows that there are two sandstones interbedded in the shales. The Henrhyd Fault crosses this little dingle 100 yards above the chapel, and throws the top of the pebbly grit 350 yards northwards.

Between the Henrhyd Fault and the Pwllau-bâch Fault the strata show signs of the proximity of the Cribarth Disturbance. There is more than one small syncline in the long southern slopes of the hill, and one in particular introduces a strip of shales which overlie the pebbly grit. These undulations also explain the fact that the outcrop of the pebbly grit is wider than the dip and the thickness would seem to warrant. Matters are further complicated near Garn-leisiau by land-slipping on a large scale. The top part of the pebbly grit, and the shale above it with a band of sandstone 6 feet thick, form a river-cliff just below Nant-y-ffin, and cross the river in succession a few hundred yards lower down. The Farewell Rock though so conspicuous at Henrhyd is not readily identified north of Glyn Llech; sandstone is seen to 18 feet alongside of the fault south of Nant-y-ffin, in a dingle at Glyn-llech-uchaf and in Glyn Llech below Melin Llech, but for the rest of its crop is buried under Boulder Clay.

The Pwllau-bâch Fault is a downthrow west of 60 yards in the Coal Measures (p. 71), and ranges for Pen-cribarth, where the much tumbled grit-slopes of the south side of Cribarth come to an end. It crosses the river south of Abercraf House and shifts the Farewell Rock to the bed and north bank. There the outcrop is clear enough; but complications set in at the old iron-works at the Rheola Arms. The Cwm-ddu Fault, which is discussed on pp. 72-74, is believed to cross the river just below the old works, and it is a fact that the strata there are vertical and inverted. The fault is supposed to range north-east and would cross the outcrop of the Farewell Rock about 300 yards east of the old works; it is a fact also that visible evidence of the outcrop of the rock ceases at that point, and that there is a small north-easterly fracture in the rock suggestive of a line of fault close by. At the old works shale dipping south at 30° to 40° lies so nearly in the line of strike of the Farewell Rock that it is difficult to say whether its true position is above or below it, but judged by its nearness to the crops of some coal-seams it must belong to the Coal Measures and be above that rock. This suggests a downthrow to the north-west on the line of the Cwm-ddu Fault.

For further evidence we have to turn to the anticline of Garth. Here, as was shown on p. 36, there is an outcrop of pebbly grit, with the limestone at or just below the surface. The grit dips north-westwards and in the hill above is followed by shale dipping at 40° to 53°, and this by the Farewell Rock. Presumably these crops sweep round the south-west end of the anticline, but of their exact position there is no evidence whatever. It is perhaps more probable than not that the whole belt of ground between the anticline and the old iron-works is faulted and overthrust.

The ravine of Nant Ceiliog commences on a slope of pebbly grit with a dip to the south-west, but to the south of the ravine the existence of the Garth anticline is shown by a series of north-westerly dips, steep enough to introduce a long synclinal trough of shale. From Tir-y-cwm downwards the ravine shows massive sandstone, which no doubt belongs to the Farewell Rock. The same rock shows up in the Giedd, but on the mountain-land between the two rivers is wholly lost to view under glacial drift.

The upper beds of the pebbly grit have been worked for silica-bricks at the west end of the Cribarth limestone-ridge. A quarry at Pen-cribarth exposes grit with a dip swinging round from south to north-west on the nose of the anticline, and another 500 yards to the north-west shows much shattered grit and shale dipping north-westwards. Between the two quarries there runs, firstly, a syncline which can be traced under a peat-bog and along the south side of a small inlier of limestone, and secondly, the Garth anticline which runs centrally through the inlier and is the reason of its existence. The massive grits, tilted up at a high angle, form several wall-like ridges, with edges scored and bevilled by ice-action.

West of the Neath, and the Tawe Valley.—continued.

By T. C. CANTRILL.

Between the Nêdd and the Tawe Valleys the basal conglomerate forms a broad dip-slope occupied by desolate moorlands. The base is often obscured by debris; but it forms a good feature round Sand Hill, and there appears to rest directly on the dark limestone with chert. From a small peat-flat west of Sand Hill to Careg Cadno it can be traced either by a crag of pebbly grit or by features strewn with blocks which have evidently not moved far out of place. West of Careg Cadno the rottenstone workings in the Upper Limestone Shales yield a ready means of locating it. A large swallow-hole 500 yards east of the Penwyllt Silica Brick Works displays a cliff of the lowest beds of the grit resting on black fine-grained limestone (rottenstone beds) containing fossils; the base can be again exactly located immediately east, and at Pen-y-foel, 400 yards west, of the works. Much of the outcrop of the basal grit is occupied by bare glaciated dip-slopes. South-west of Careg-lwyd crag after crag breaks out, each probably underlain by a thin parting of shale, an insecure foundation which has led to the slipping of many great blocks of grit.

In this region as elsewhere along the base of the grit, patches of white and yellow grit-debris occur far down on the limestone outcrop, and boulders of similar rock abound in the drift. Though some may have been derived from bands which there is reason to think are interbedded in the limestone, the larger patches, on the contrary, are probably derived from the Millstone Grit. Thus a large spread of debris conceals much of the limestone immediately west of Carn yr Onen; and east of Pwll Byfre a thick pocket of like material in a loose sandy condition extends from near the base of the Millstone Grit northwards to the northern margin of the limestone. This debris without doubt consists of Millstone Grit material and has been let down into its present position by solution and collapse of the limestone. It was being dug in 1898 for silica-sand by the Penwyllt Company.

Swallow-holes on the outcrop of the grit are frequent; they are funnel-shaped where the grit is rotten or in a fragmentary condition, but often have precipitous joint-faced walls where it is well preserved. Examples occur near the peat-flat west of Sand Hill; Pant Mawr Pool, south of the latter, appears to lie in a hollow of subsidence.

The Millstone Grit can be seen in the Tawe 200 yards north of St. Callwen Vicarage to rest on black argillaceous limestone. West of Craig-y-nôs the grit is rolled down in a syncline which forms part of the Cribarth Disturbance, and thin bands of interbedded black shale are shown in old sand-pits along the synclinal axis. North-west of this locality the grit forms extensive slopes of which Castell y Geifr, Careg-gôch, Dysgwylfa, and Careg-lem are the most salient features. On all of these the rock is well displayed, and its base can be accurately located by the rottenstone-workings.

Here again the crop of the limestone is much encumbered with grit-debris. One most interesting patch occurs 350 yards north-east of the edge of the grit at Castell y Geifr, and at a considerably lower level. It forms a low elliptical mound, about 100 yards long and 70 broad; and around part of its margin rottenstone has been dug. The mass is surrounded by drift and lies on the outcrop of the lowest sub-division of the Main Limestone. It is conceivable that the mass gradually slid down as a landslip, but it is doubtful if it could have reached its present position in such a manner without breaking down into scattered blocks. More probably it gradually sank some 200 or 300 feet vertically downwards by the solution of the underlying limestone.

A similar case of subsidence has been noticed between the Giedd and the Twrch. Rottenstone has been dug out of the glacial drift 250 yards south of the point indicated on the map by a dip-arrow of 9° south of Carnau Gŵys. This drift lies on the dark limestone, No. 2 of the Section on p. 20, which forms the lower part of the Main Limestone, at a distance of half a mile from the nearest points of the outcrop of Millstone Grit and rottenstone-shales. Landslipping is here out of the question, for the slope is in the wrong direction, nor is it possible that the material was glacially transported, for the ice moved towards the Millstone Grit area. In this case the subsidence amounted to about 400 feet and took place previously to the glaciation, the effect of which was to mingle the rottenstone debris with the northern drift.

The form of the ground on the grit-outcrop often renders it possible to locate lines of drainage in the underlying limestone, for there are some dry valleys towards which the beds dip and which are evidently lines of subsidence. A case in point occurs at the head of Nant Ceiliog, a mile west of Craig-y-nôs Castle.

The shale sub-division of the Millstone Grit forms the moorlands of Dorwen-ar-Giedd and Cefn-mawr. The base of the sub-division is somewhat indefinite, and is localised generally by the cessation of the crags and dip-slopes of the underlying grit, and by changes in the angle of slope of the ground and in the aspect of the vegetation. A small section showing rusty black shales in place is indicated on the map by a dip-arrow on Dorwen-ar-Giedd. No sections have been observed on Cefn-mawr, and both the Giedd and the Gŵys show nothing but drift.

What appears to be a small outlier of these shales lies along the north-west side of the peat-flat at the head of Nant Ceiliog, but no exposures occur.

Fossils from the Shales of the Millstone Grit.

By A. STRAHAN.

The fossils in the following list have been obtained from shales below the Farewell Rock and above the basement-grit of the Millstone Grit. As a general rule the *Carbonicola* occurs in the upper part of the shale, while purely marine forms such as the crinoids, brachiopods and cephalopods are confined to the lower part. Thus localities 1 and 2 give a higher horizon than localities 3, 4 and 5. It should be remembered, however, that a true marine fauna reappears in the Coal Measures. Localities 13-17 lie within Sheet 232, but the fossils from them, having been collected since the publication of the memoir descriptive of that sheet,* are recorded here. The following list should be compared with that given on pp. 47, 48 of the memoir referred to. The identifications are by Mr. E. T. Newton, F.R.S., and Dr. F. L. Kitchin.

Localities.

1. Pitwellt Stream near Dowlais; 200 yards east of the L. & N.W. Railway.
2. Waterfall on a tributary of the Pitwellt, midway between the L. & N.W. and the B. and M. Railways.
3. Pitwellt Stream, 100 yards north of the tributary.
4. Pitwellt Stream, below the B. & M. Railway.
5. Pitwellt Stream, above the B. & M. Railway.
6. A tributary of the Pitwellt, above the B. & M. Railway.
7. Nant Ffrŵd, near Cefn.
8. Road west of the Hepste, 1¼ miles N.N.W. of Penderyn Church.
9. Ravine in north bank of Hepste, above Ysgwd yr Eira.
10. Under Ysgwd yr Eira.
11. Two hundred yards N.N.E. of junction of Nant Llechau with the Nêdd.
12. East end of Pencaedrain Tunnel.
13. Dingle near Hafod Farm, 1½ miles N.E. of Brynmawr Station.
14. Pwll-côch, 2 miles N. of Beaufort Station.
15. Cwm Carno, 1⅛ miles N. of Beaufort Station.
16. Blaen-y-cwm, ¾ mile N. of Nant-y-bwch Station.
17. Blaen Rhymney, ½ mile N. of Rhymney Bridge Station.

List of Fossils.

Crinoid-stem ossicles, 5, 16.
Poteriocrinus ? 17.
Rhodocrinus sp., 17.
Annelid burrow, 4, 17.

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* Geology of the Country around Abergavenny (*Mem. Geol. Survey*). 1900.

Spirorbis pusillus ? *Mart.*, 5.
Dithyrocaris sp., 8.
Chonetes ? 13.
Discina nitida, *Phill.*, 7, 8, 17.
Discina sp., 11.
Lingula mytiloides, *Sow.*, 1, 2, 4, 5, 6, 7, 8, 10, 13, 14, 16, 17.
Orthis Michelini, *Lév.*, 17.
Productus semireticulatus, *Mart.*, 4, 5, 7, 11, 13, 16, 17.
Productus sp., 15.
Spirifera glabra, *Mart.*, 13, 17.
Spirifera ? 8.
Strophomena ? 13.
Anthracomya ? 3, 5.
Carbonicola acuta, *Sow.*, 3.
Carbonicola aquilina ? *Sow.*, 12, 17.
Lithodomus lingualis, *Phill.*, 13.
Nucula gibbosa, *Flem.*, 5.
Nucula undulata, *Phill.*, 8, 17.
Nuculana attenuata, *Phill.*, 4, 5, 6, 7, 8, 16, 17.
Nuculana sp., 13.
Pinna sp., 2.
Posidoniella minor, *Brown*, 9 ? 10.
Pterinopecten papyraceus, *Goldf.* (Aviculopecten) 8, 9, 10, 16, 17 ?
Loxonema ? 8, 16.
Pleurotomaria (Ptycomphalus) atomaria, *Phill.*, 4, 5, 7, 17.
Pleurotomaria sp., 8, 13, 16.
Turbonellina ? 8.
Gastrioceras carbonarium, *von Buch*, 6.
Gastrioceras Listeri, *Mart.*, 17.
Glyphioceras bilingue, *Salt.*, 4, 8, 9, 10 ?
Glyphioceras reticulatum, *Phill.*, 4, 5, 7, 8 ? 10, 16, 17.
Nautiloid, 4, 8.
Orthoceras, 17.
Pleuronautilus cf. falcatus, *J. de C. Sow.*, 13, 17.
Palæoniscoid scale, 1.
Strepsodus (scale) 2.

CHAPTER V.

CARBONIFEROUS ROCKS (*Continued*).

COAL MEASURES.

Introduction.

By A. STRAHAN.

The part of the North Crop included within the area under description extends from the anthracitic region of Ystradgynlais to the steam-coal region of Dowlais. While not always recognisable individually, the lower coals as a group can readily be identified in the two regions. The Ras Las or Nine-foot Seam of Dowlais and Aberdare corresponds pretty closely in position with the Big or Nine-foot of the anthracitic region, while the Two-foot-nine is supposed to be the Stwrain Vein. The anthracitic region is regarded as commencing at the Vale of Neath, but there appears to be no definite boundary between it and the steam-coal area. Moreover, the anthracitisation is far from complete in the Vale of Neath, and continues to increase westwards beyond the limits of the map under description. Though all the seams are subject to the loss of bituminous matter in a westward (or more strictly north-westward) direction, the lower seams are the first to show it. Thus in any one vertical sinking the lower coals are on the whole less bituminous than the upper. Fuel for malting purposes is obtained from the Big and Brass Veins in the Dulais Valley and west of it. The Red Vein, which lies 270 yards below No. 2 Rhondda, and therefore about 230 yards higher than the coal known by that name at Dowlais and east of it, first appears as a workable coal in the Dulais Valley, and runs thence westwards as far as the Loughor Valley (Sheet 230).

From an account given by Alderman John Winstone * it appears that the value of the steam-coal of Merthyr was first recognised about the year 1835 by Mr. Nixon. A small colliery on the mountain side between Aberdare and Merthyr, called the Warfa [Werfa] Colliery, was developed, an incline made to the Aberdare branch of the Glamorgan Canal, and the first boat-load of steam-coal sent down to Cardiff in the year named.

About forty-five years previously "the principal part of the coal used at Aberdare for household purposes was brought from Trebanog in Cwm Rhondda, a distance of twelve or thirteen miles, on horseback over the mountains." †

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* "Reminiscences of Old Cardiff," *Trans. Cardiff Nat. Soc.*, vol. xv.. 1883, p. 74.

† A statement made to Sir H. T. de la Beche by Mr. Williams of Garth Hall, Llantrisant, and recorded in one of De la Beche's note-books.

The No. 2 Rhondda Seam has been selected as the top of the Lower Coal Series for reasons which are given elsewhere.* Briefly stated they consist in the fact that that seam marks the lower limit of the main mass of sandstone in Monmouthshire, and that it alone could be traced continuously thence through Glamorganshire. The scarp of Pennant above No. 2 Rhondda assumes grand proportions between the Cynon and Neath, but the Llynfi Rock, which develops below it in the Cynon Valley, grows in importance westwards and forms great crags, such as Craig-y-Bwlch and Graig-lwyd.

The faults are discussed in detail in the following pages, and it will suffice now to point out that all those affecting the Coal Measures of the tract under description belong to the N.N.W. system, with the exception of the great disturbances of the Vale of Neath and of Cribarth. Although a large number of the N.N.W. faults have been traced both to the north and south of the Neath Disturbance, none can be proved to cross it in this district. One or two may do so, but the majority certainly do not. Some over-thrusting and strong folding in the lower measures have been noticed, especially from Hirwaun westwards, which may be connected with the Neath movement. The structures have not been noticed in the Llynfi and Pennant grits, but have been proved in places to affect the lower and softer strata under apparently undisturbed tracts of those massive rocks.

The measures in which the principal seams lie are illustrated in *Vertical Sections*, Sheet 83, Nos. 1, 2, 12, 13; Sheet 84, Nos. 12, 13, and 19; and Sheet 85, Nos. 12–16.

THE LOWER COAL SERIES.

The Taff Valley.

By W. GIBSON.

The Lower Coal Series of this valley is illustrated by the shaft-sections of the Dyffryn South Pit, Castle Pit, Plymouth Iron works, and a section taken near the Merthyr Tunnel (*Vertical Sections*, Sheet 83, Nos. 1, 2, 12, 13). The relative positions of the chief seams are shown in the section given on p. 90. On the east side of the valley the lower ironstones lying between the Farewell Rock and Lower Four-feet or Gellideg Coal were formerly extensively worked in the "patchworks" north of Dowlais Top Station. Old crop-workings in the Ras Las and Upper Four-feet Seams extend from the eastern margin of the map for about a mile to the south-west, and as far as the Taff Valley old shafts and abandoned patches abound. These seams are now worked from shafts situated lower down the valley.

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* Geology of the Country around Pontypridd and Maesteg (*Mem. Geol. Survey*), 1903, p. 7.

The Nine-feet Vein crops out at an elevation of 530 feet above Ordnance datum under the alluvium of the Taff to the east of Glyndyrys Pond, but was reached in the Castle Pit at a depth of 360 feet below that datum. This difference in level of 890 feet, in a distance of a little under one and a half miles, indicates an average rise of one in eight or about 7°.

The Castle Pit commences approximately 200 yards above No. 2 Rhondda, and reaches the Upper Four-feet Coal at a depth of 250 yards, proving the distance between the two seams to be about 450 yards. The strata consist of dark-grey shales, thin bands of grit, and thin seams of coal. Many of the grits are highly siliceous, while those in the upper part are coarsely conglomeratic, and give rise to conspicuous features, such as may be seen south of Merthyr Common. The less purely quartzose varieties so closely resemble Pennant Grit that a thin coal underlying a grit-band of this character, and which was formerly worked from the Saron Level at Troed-y-rhiw, is locally regarded as being No. 2 Rhondda. That this identification is wrong is proved by the fact that No. 2 Rhondda crops out just above the shafts of the Merthyr Vale Colliery to the south (Sheet 248), whereas the coal of the Saron Level must lie at a considerable depth in these shafts. Moreover, the distance between the Upper Four-feet Coal and the seam in the Saron Level does not much exceed 150 yards, while both at Merthyr Vale and near the Castle Pit, No. 2 Rhondda and the Upper Four-feet are 450 yards apart.

On the west side of the Taff the crops of most of the lower coals are buried under drift, and their positions have been taken from old plans. South of Nant Ffrwd the ironstones known as the Rosser Veins * were formerly obtained in open workings. They lie a few feet above the Farewell Rock, which is seen in a small dingle to the west of Tai-mawr.

The Gellideg or Lower Four-feet, the Nine-feet and the Upper Four-feet Seams have been both patched and worked by levels on the north-eastern flanks of Mynydd Aberdare. Some levels are still in use, but the work is now chiefly confined to the Castle Pit. A section of the Nine-feet Seam showing more than seven feet of coal occurs in a patchwork to the west of Ochr-y-Mynydd. A little further to the west, the Six-feet and Two-feet-nine Seams come close together, and were worked from the same level. A thin coal associated with black shales and ironstones, and agreeing in position with the Elled Coal of Monmouthshire, has been "patched" for a considerable distance to the south-west of Pen-yr-heol-gerig.

The measures lying above the seams last referred to, and below No. 2 Rhondda, resemble those on the east side of the Taff, but the grits are more pronounced and boldly outline the landscape on Mynydd Aberdare and Pen-y-lan Hill. The summit of Mynydd

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* In Monmouthshire the same name is applied to some ironstones lying in the shales under the Farewell Rock.—Geology of the Country around Abergavenny (*Mem. Geol. Survey*), 1900, p. 38.

Aberdare is capped by red and grey flags, interstratified with a strong quartz-conglomerate resembling that at the base of the Millstone Grit. The grits on the east side of Pen-y-lan Hill are exceedingly like Pennant grit and overlie thin coals, one of which, about two feet thick, has been opened out by a level a quarter of a mile south of Graig farm. This appears to be the seam known as "Spratts Coal" a little to the north of the Graig. A seam, over one foot thick and about seventy yards higher in the sequence, is likewise overlain by a massive Pennant-like sandstone, which is much quarried south of the Castle Pit. The coal is known as the Castell Weaver Seam, and is fifty-five feet below the mouth of the Castle Pits. A few thin seams are met with higher up in the sequence, but none can be identified with No. 3 Rhondda.

The Cynon Valley.

By W. GIBSON.

The succession is illustrated by the shaft-sections of the New Pit, Aberdare Ironworks, and the George Pit. (*Vertical Sections,* Sheet 83, Nos. 4 and 14.)

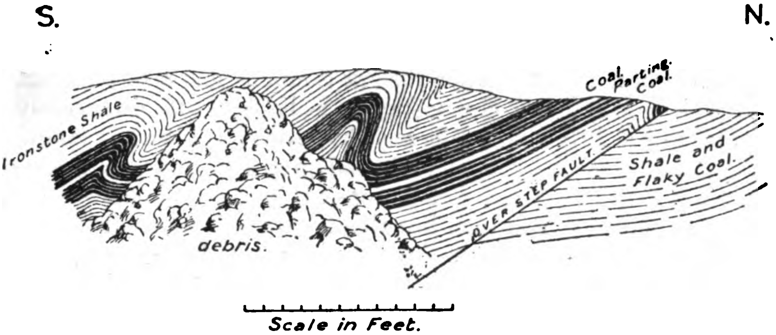
An interesting point in connection with the Lower Coal Series is the presence on the eastern side of the valley of small overthrust faults, such as may be seen in Groesdy Patch 300 yards north-west of Ysgubor-wen House. Disturbances of this kind grow in intensity in a westerly direction.

Owing to a thick cover of Boulder Clay little rock is visible at the surface on the east side of the valley. The lower ironstones and coals were got in patchworks north of Grey's Place. The Nine-feet has been worked from a level situated near the river side 150 yards north of Abernant House, and is found at a depth of 128 yards in the Cwm-bach Pits; which reached also the Gellideg Coal at 188 yards. The grits below No. 2 Rhondda are strongly developed, and have been much quarried to the east of Abernant and Cwm-bach. To the east of the last-mentioned locality a thin coal overlain by a massive grit has been opened out by several levels between Lletty Shenkin and Tyle Robert. At a vertical distance of 100 yards below it a second seam has been tried. This is situated 160 yards above the Upper Four-feet of the Cwm-bach Colliery. From the west side of the Cynon the Lower Coal Series extends in a broad outcrop from Aberdare into the Vale of Neath. There are few collieries on that tract, but advantage has been taken of the deep cwm of Bwllfa Dare to reach the lower coals in shafts. The chief collieries are those of the Bwllfa and Merthyrdare companies.

The Cnapiog (or Knobby) Ironstone, the equivalent of the Garw Ironstone of the Dowlais district, crops out in the Knobby Drift a quarter of a mile to the south of Hirwaun. The Nine-feet Seam comes to the surface 800 yards to the south of this and the Two-feet-nine Seam in the drift of the Bryn-gwyn Colliery, 300 yards to the south of the Nine-feet, both dipping southwards at 6° or 7°. Some old patchworks to the east shew an interesting structure in the measures between them, for the strata are much contorted though a band of grit cropping out a short distance to the south is undisturbed. On the western side of Slade's Patch a thin coal is bent up in a sharp anticline dislocated by a small overthrust fault, as illustrated in the following sketch (Fig. 1).

FIG. 1.—*Folds and Overthrust in Slade's Patch, Hirwaun.*

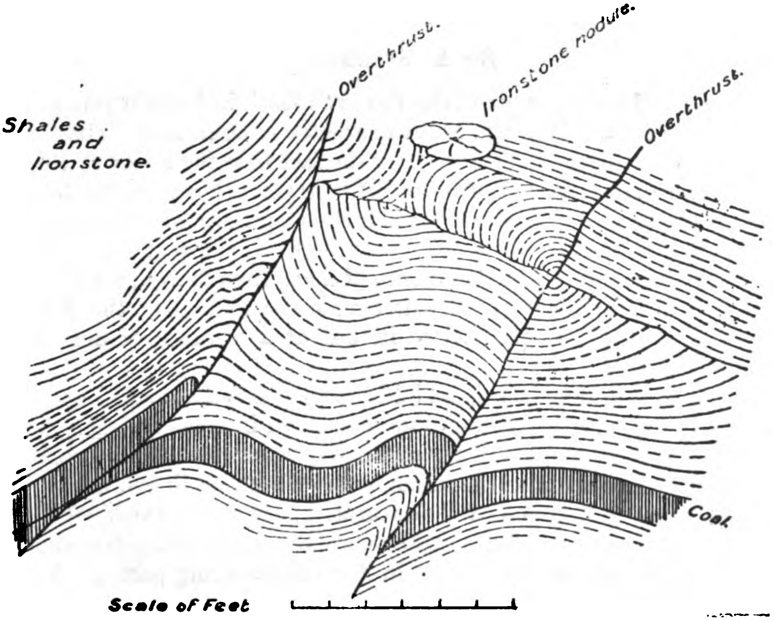
By W. GIBSON.



Close by in the same excavation there are other small overthrusts, complicated by a nearly horizontal fracture by which gently inclined shales have been thrust over contorted shales, as shown in Fig. 2.

FIG. 2.—*Folds and Overthrusts in Slade's Patch, Hirwaun.*

By W. GIBSON.



That these sharp rolls are not confined to the margins of the North Crop is shown in the underground workings south of the Merthyrdare Colliery. There the Seven-feet Vein, at a distance of 500 yards south of the colliery, commences to rise locally to the south at one in three, though the grits at the surface show no such inclination.

The increase in thickness of the grits above the Two-feet-nine Seam, as compared with the ground to the east of the Cynon Valley, is important. West of Aberdare one of these bands has swollen out into the bold crags of Craig-y-Bwlch, Craig yr Ysgol, and into the high scarp overlooking Cwm Dare. Such crags have all the appearance of those carved out of the Pennant, and the resemblance is almost complete when the grit is impure and rests on a thin coal, which under such circumstances is liable to be erroneously regarded as No. 2 Rhondda. The rock, however, is subject to a lateral change, and becomes a flaggy pink and grey grit, with less resemblance to Pennant. A coal which crops out in the Cwm Dare Valley and to the south of Aberdare, lies about 100 yards vertically below the base of this grit. From Cwm Dare it can be traced round Mynydd Cefn-y-Gyngon, where it lies a little over 100 yards above the Two-feet-nine Seam. It is known as the Graig Seam, and is locally considered to be No. 3 Rhondda. This does not agree with the 282 yards separating these seams in the Maerdy Pit in the ground to the south; but, on the other hand, it closely approximates to the distance between the Abergorki and Two-feet-nine Seams in the Rhondda Valley. The Graig Seam occurs a few feet below some light-red or grey conglomeratic flaggy grits, which can be best seen in Craig Coed and on Mynydd Cefn-y-Gyngon.

Hirwaun to the Vale of Neath.

By A. STRAHAN.

The Coal Measures succeed the Farewell Rock in Cwm Wyrfa with a disturbance of which the exact character is unknown. That the strata are sharply folded is shewn by the fact that the Farewell Rock with some shales above it dips at 35° to the south-east in the lower part of the brook, while a few yards further up the shales dip equally steeply in the opposite direction. South of this sharp syncline there is an anticline, and repeated evidence of sharp though local plications. These structures repeat on a small scale the folding of the Neath Disturbance and run parallel to it, but at a distance of one mile south-east of it.

On the south side of this local fold the measures assume the normal southerly dip and the mine-ground comes on in proper place. The lowest coal seen crops out at Gwrangon, where it is being worked for local purposes under the name of the Queen or Enoch Seam; it is said to be a "stone-coal" (anthracite), two feet thick. Other small seams cross the dingle 200 and 350 yards south of Gwrangon fawr. There are two crops also in the neighbouring part of Nant Gwerelech, south of Rhyd-groes.

At Beili-glas a slope has been recently worked in the Nine-feet Seam, and another in the same seam 180 yards up Cwm Ceffyl; 250 yards further up the same cwm the Lower Four-feet Seam crops out and has been worked by level. The facts that these crops lie nearly in the direction of level course of the crops of the lower seams visible near Gwrangon, and that the Nine-feet and Lower Four-feet have not been recognised in the Gwrangon dingle, remain unexplained. The Lower Four-feet Seam is seen again in Cwm Tyr-mynydd, but with a crush just below it. The water-adit of the British Rhondda Colliery opens into this cwm, and 100 yards north of the adit-mouth a coal 2 ft. 6 in. thick crops out; while near the mouth of the dingle there may be seen sandstone and dark shale overlying one foot of coal and black dirt with one foot of coal below. Which of the lower seams these represent it is difficult to say.

Of two seams visible in a water-course due west of this place, and 200 yards west of Iestyn-gwerelech, the upper is said to be the Bluers, while on the opposite or north side of Nant Gwerelech the Cnapiog has been worked by level on the crop. Probably it is these two which appear in Cwm Tyr-mynydd. The following descending section was noted in the water-course west of Iestyn-gwerelech :—

Nant Gwerelech.

	FT.	IN.
Coal (? Enoch or Cnapiog)	1	6
Black shale	6	0
Coal	0	4
Black shale	3	0
Coal	1	0
Stone, impersistent	0	6
Clay with nodules of ironstone, seen to	10	0

Much ironstone was formerly raised from Nant Gwerelech, partly by level but chiefly by open excavation in the sides of the ravine and on the mountain. The mine crops out on the slopes overlooking the Neath Valley and recourse was had to "scouring," that is to washing the ironstone out of its matrix by suddenly liberating a flood of water. The gashes thus caused are still conspicuous, and some acres of ground south-east of Ynys-onws are overspread by the detritus from them.

The following section of the mine-ground at Aber Gwer-elech has been condensed from a detailed section supplied by Mr. T. Criswick, M.E.

Aber Gwerelech.

	YDS.	FT.	IN.
Rock top	——		
Shale with courses of mine. The Eleven Pins Mine	3	1	5
Shale	0	1	11
Coal	0	0	3
Good fireclay	1	2	6
Fireclay	1	1	0
Strong and dark shale	3	2	6
Mine-ground	6	0	3¾
Strong rocky shale	3	2	6

	YDS.	FT.	IN.
Rock	1	2	0
Shale	4	0	6
Mine-ground. The Five Pins Mine	1	0	9
Dark shale	1	2	6
Coal	0	1	8
Dark shale	1	0	0
Coal	0	0	1
Pouncing	1	0	0
Coal	0	0	3
Good fireclay	1	1	0
Coal	0	0	6
Pouncing and shale with large balls of mine	6	0	7
Shale and mine-ground	8	0	5
Mine-ground with four courses of mine. The Blewers Vein	4	0	11½
Shale	1	0	7
Blewers Coal	1	0	0
Fireclay	1	0	0
Clift and rock	7	1	11
Mine-ground with three courses of mine. The Brown Vein	0	2	8½
Dark shale	0	2	7
Coal	0	1	0
Fireclay	2	0	0
Hard clift	1	2	0
Mine-ground with three courses of mine. The Rhied Vein	0	2	9½
Shale	2	0	6
Coal	0	0	11
Shale and rock	5	2	6½
Dark shale with Yellow Pin in the middle	1	1	2
Mine-ground with three pins of mine. The Spotted Vein	2	0	4
Fireclay and shale with mine	6	0	4
Mine-ground with three pins of mine. The Blue Vein	2	0	9½
Shale with mine and some rock	4	2	8½
Mine-ground with three courses of mine. The Little Blue Vein	2	1	8¾
Rock and clift with mine	4	1	10
Mine-ground with four courses of mine. The Knobby [Cnapiog] Vein	2	2	11½
Dark shale and bass	1	1	6
Balls of mine	0	0	3
Dark shale	0	2	3
Garw Mine	0	0	3½
Mine-ground	0	1	10
Garw Coal	0	1	8
Fireclay	1	0	11
Rock and mine-ground	1	1	8
Mine-ground with two courses of mine. The Upper Rosser Vein	1	2	11
Dark shale with two pins of mine	6	2	9½
Mine-ground with one course of mine. The Middle Rosser Vein	3	0	2½
Shale with mine	4	0	3
Mine-ground with two pins of mine	1	0	7
	129	1	1½

The Cnapiog Seam, showing one foot ten inches of coal, is well exposed in an old quarry traversed by the tramway of the British Rhondda Colliery, and a dingle close by on the west shows a higher coal which is presumably the Enoch. A considerable thickness of shale and clift separates the Cnapiog Vein from the top of the Farewell Rock.

The slope of the British Rhondda Colliery is driven on the Nine-feet Coal; an old slope 350 yards up the incline is on the Upper Four-feet, while the Driver Coal can be seen 150 yards further on again. A fault with a downthrow west of ten yards runs nearly parallel to the tramroad, but about 100 to 120 yards east of it. The following measurements were furnished by Mr. W. T. Rowlands, Manager:—

British Rhondda Colliery.

	YDS.	FT.	IN.
Driver Coal -	0	2	2
Measures - -	13	0	0
Upper Four-feet Seam, 3 ft. 6 in. to - -	0	4	0
Measures - -	19	0	0
Six-feet Seam (or Eighteen-feet of Abergwm) - -	2	2	0
Measures - -	9	0	0
Lower Four-feet Seam - -	1	0	0
Measures - -	28	0	0
Nine-feet Seam, 8 ft. 6 in. to	3	0	6
Measures - -	21	0	0
Bute Seam -	0	0	6
Measures containing the Bluers, Enoch, and Cnapiog Seams - -	——		

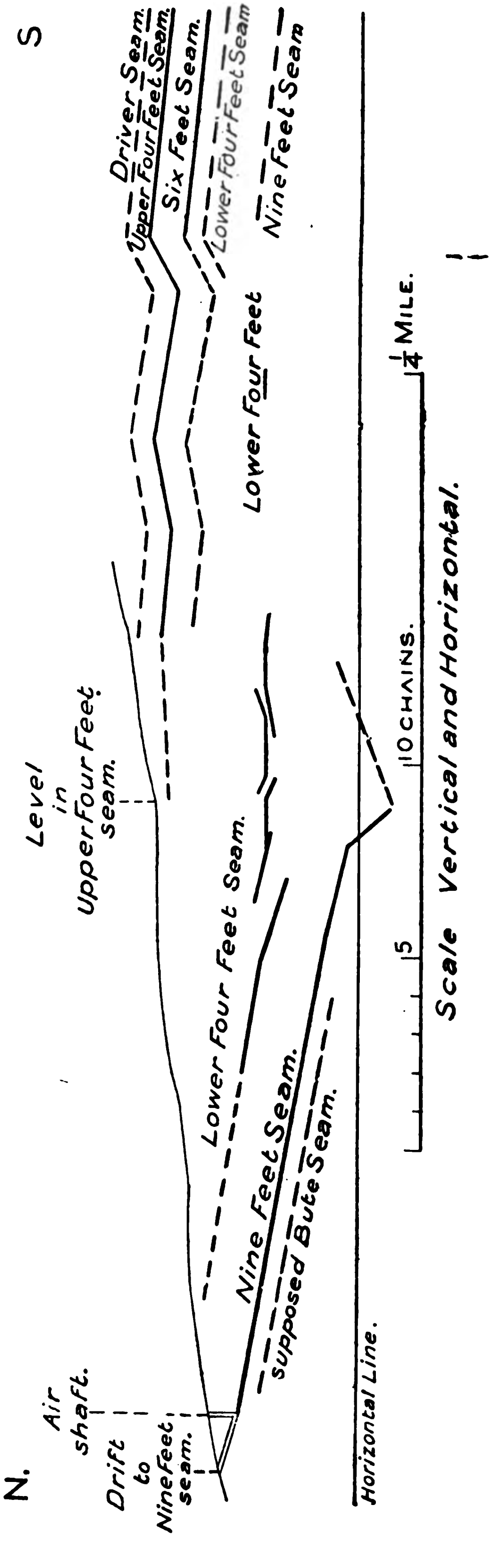


FIG. 3.—*Overthrusts in Davies' British Rhondda Colliery, Glyn Neath.*

The crop of the Nine-feet Seam has been found in Nant Hir also, and the seam has been worked as far as Nant Rhyd-y-gau where a fault was touched. An abandoned slope by the side of the tramway to the Dunraven Adare Colliery is said to have proved the crop of the same seam to the west of the fault.

The measures all along this hillside are much disturbed, as may be seen in any of the dingles. The workings of the British Rhondda Colliery give a particularly instructive example, showing how pressure has been relieved partly by folding, partly by overthrusting. In the section forming Fig. 3, the coal-seams are represented by continuous lines where they have been proved. It will be observed that the Nine-feet Seam bends so sharply down between sixteen and seventeen chains from the mouth of the drift that it was impracticable to follow it, while the Four-feet Vein shows this fold in a much modified form, but accommodates itself to a reduced space by repeated overthrusting. The strata are overthrust from the south on the north side of the trough, but from the north on the south side.

Cwm-gwrâch is a deep ravine in the lower measures, leading down to Glyn Neath Station. The Rosser Veins crop east of the Infant School, and the Bluers Vein further up the ravine, the section of the latter according to Mr. Morgan W. Davies being as follows :—

Bluers Vein, Cwm Gwrach.

	FT.	IN.
Rashes	1	0
Bast	0	4
Coal	2	0
Parting	0	2
Coal	0	9

Vale of Neath (continued).

By W. GIBSON.

On the east side of the Neath Valley the numerous streams and deep channels flowing down from the Pennant escarpment lay open the Lower Coal Series from the horizon of No. 2 Rhondda down to the Enoch Vein. The strata between No. 1 Rhondda and the Aberdare Six-feet Seam are penetrated by the shafts of the Cwm Clydach Colliery, Resolven (*Vertical Sections*, Sheet 85, No. 12.)

The best exposures of the lower portion of the series are afforded by the numerous streamlets issuing from the foot of Craig-isaf. The strata are thrown into a number of small but sharp folds, which, however, failed to produce any effect upon the thick beds of grit. Cwm yr Argoed, a little north of Blaen-gwrâch, yields an example of an undisturbed grit, both underlain and overlain by sharply folded shales. At first sight the junction suggests an unconformity, but the apparent discordance is due to the fact that the grit-band offered sufficient resistance to the pressure to escape folding, while the shales easily yielded.

The Enoch Vein crops out near the junction of Cwm yr Argoed and Cwm-gwrâch while the Yard Vein crosses the main stream one hundred yards further up. The Upper Four-feet, a little over four feet thick, has been opened out by a level in the northernmost of the cluster of streams about 100 yards to the west of a bye-road from Cellar. Three hundred yards to the west the stream cuts across the Nine-feet Vein, of which over three feet is visible.

The measures above the Four-feet Seam consist of alternations of grits, each resting on a thin coal, with grey and yellow shales; they are deeply trenched again and again by the streamlets flowing from Mynydd Resolven. The shales near the summit contain nodules of ironstone in which the entomostracan *Carbonia* is fairly abundant. The streams flowing down from Craig-y-Llyn yield further exposures, and the overflow from Llyn-fâch intersects the Gorllwyn Seam to the east of the Rhondda Mountain Colliery. This seam is sometimes regarded as the base of the Pennant Series, and is said to mark the separation of the Red Ash Coals above from the White Ash Coals below. It is certainly a fact that bands of grit are more numerous above than below this horizon, but it is not possible to trace the Gorllwyn for any distance, or to satisfactorily correlate it with any of the known seams to the east of the Cynon Valley. Its most likely equivalent is the Elled Coal of Monmouthshire, which also lies at a horizon where shales with thick coals give place upwards to grits and shales with thin coals.

North of the Neath.

On the north-west side of the Vale of Neath, opposite Resolven, the measures are thrown up to a considerably higher level than on the east side by the Neath Disturbance; No.1 Rhondda, for example, is on a level with the alluvium near Resolven Station, and not more than 100 feet above sea-level, while it reaches the 900-feet contour immediately opposite. Many sections occur in the Crugau and Rheola Brooks. The bulk of the material is made up of dark-grey shales, frequently thrown into folds, and beds of hard grit resting on thin coals. A band of coarse grit 200 feet below No. 2 Rhondda is underlain in Craig Nêdd by a coal two feet six inches thick with a bed of fireclay beneath it.

North of the Neath (continued).

By A. STRAHAN.

It has already been stated that the measures are thrown down northwards by the Neath Disturbance near Glyn Neath. Accordingly we find productive Coal Measures cropping out on the north side opposite the spot where the Farewell Rock and Rosser Veins crop out on the south side, and have to proceed nearly two miles north-eastwards before we reach the lower rocks again. The Farewell Rock forms an eminence behind Dinas Rock Inn; it dips south-eastwards, but either turns over or is faulted down, for in Nant Gwyddel close by the Cnapiog Vein has been worked by levels. The dip is at a gentle angle down the dingle and the crop of the coal runs along the west bank under a bed of rock as far as the mouth of the tributary from Bryn-ceffylau, where a level shows sandstone sixteen feet thick, resting on sixteen feet of shale with the coal below it. In this tributary the Black Pins mine-ground has been worked, while to the south-west of it there are old levels and patchworks on the Bluers Vein, and a level which shows the Bluers Coal to a thickness of two feet. At the head of the same tributary, at Bryn-ceffylau, there is a level in which the Yard (Brass) Vein is visible to a thickness of two feet; this coal has been opened also 230 yards south-west of Derwlwyn-mawr and crops out in Pergwm Brook under a waterfall 1,050 yards above Aberpergwm House, where it is two feet two inches thick. The Yard Vein though not now worked is said to be a good coal, two feet ten inches to three feet three inches thick.

The measures above the Yard Vein have been proved in the workings of the Aberpergwm (Pwll-faron) Colliery, and in the neighbourhood, to present the following sequence, according to information supplied by Mr. Griffiths:—

Aberpergwm.

	Yds.	Ft.	In.
Upper or White Four-feet Seam, 3 ft. 10 ins. to	1	1	0
Measures	22	0	0
Eighteen-feet Vein, 4 yds. to	5	0	0
Measures	8	0	0
Four-feet Cornish Vein	1	1	0
Measures	32	0	0
Nine-feet Vein, 3 yds. to	3	2	0
Measures	24	0	0
Yard Vein, 2 ft. 10 ins. to	1	0	3

The coals, according to Mr. Daniel Rees, Manager, are all about the same quality, and are intermediate between steam-coals and true anthracites. The Four-Feet Cornish Vein has at its bottom about ten to twelve inches of black material known as "cornish" or "bast." Though having the fracture of cannel, "cornish" is devoid of gas and useless as a fuel, and the value of the Four-Feet Vein is impaired by its presence. The Nine-feet Vein shows top coal two feet three inches, middle coal, two feet, and bottom coal, five feet six inches thick; in the bottom coal, about twenty to twenty-six inches above its base, there is a band of pyrites from three to five inches thick. The band appears as a black finely granular rock and has been used for building walls and barns in the neighbourhood.

The crops of these veins are repeatedly exposed to view in the wood traversed by Pergwm Brook. In the Eighteen-feet Seam there are small ravines with walls of solid coal north-west of Aberpergwm House, and the same coal is well shown in Nant y Cwrfa as well as at several places along its crop across the mountain eastwards. The Cornish Vein with the "cornish" below it, can be examined at a waterfall 750 yards north-west of Aberpergwm House, again in Nant y Cwrfa, and at the point where it intersects the 700-feet contour. The Nine-feet Seam also may be found without difficulty, but the Upper Four-feet is seldom exposed to view. Though generally about twenty-two yards above the Eighteen-feet Seam the Upper Four-feet was found to lie locally close above it, 900 yards east of Blaen-pergwm, but whether through squeezing out of soft measures or a "wash-out" could not be ascertained.

A fault, with a downthrow west variously estimated at twenty-four and forty-five yards, runs nearly under the office of the colliery. It was worked up to in the Nine-feet Seam under Nant y Cwrfa and further north in the Upper Four-feet, and was proved to range nearly for the Glyn Corwg Fault. It is questionable, however, whether the Glyn Corwg Fault crosses the Neath Disturbance. If it does it loses the greater part of its throw in so doing, for the displacement on Resolven Mountain, though difficult to estimate precisely, certainly much exceeds forty-five yards. What is believed to be a more important fault has been touched in the Eighteen-feet Vein; it is said to be a downthrow west and to pass between Maes-gwyn and Pentre-clwydau, but no satisfactory evidence of its existence has been forthcoming. Four faults, of no great importance, can be detected in the Pennant scarp close by. One of them, ranging about E.S.E. is a downthrow north of twenty-five feet, but hades to the south; another can be traced across the mountain to the Dulais Valley, where it is known as the Pwllau-bach Fault (p. 68).

Other disturbances abound in the southern end of Aberpergwm Wood. The measures affected are those which lie between the Eighteen-feet Vein and the base of the Pennant. The Nine-feet Vein crops out in an old patch close to Pwll-faron with the Eighteen-feet just above it, both having a north-westerly dip. The next dingle to the south, however, shows repeated sharp rolls with indications of overthrusting, while similar appearances are presented in a water-course which reaches the high road 750 yards south-west of Pwll-faron; in parts of it the strata dip southwards, while in two places they are vertical, with an east and west strike. The measures again dip southwards in parts of the dingles half a mile north of Pwll-faron, evidently through the effects of sharp rolls trending approximately east and west. Clwydau Brook has cut a deep ravine in shales with thin coals, showing frequent signs of deformation and overthrusting. Sandstone dipping west at the mouth of the dingle is succeeded abruptly about 300 yards up it by shale dipping N.N.W. at 68°, and this again is overlain by an even-bedded sandstone with a low inclination, which seems to have been thrust over it. Then follows a succession of shales with three coals, six inches, four inches, and twelve inches thick respectively, which dip generally N.N.W. at 24° to 30°. At 700 yards from the mouth there is a waterfall thirty-five feet high, with a coal fifteen inches thick half way up and another six inches thick at the base; 130 yards farther on there is a coal twelve inches thick, and 170 yards above the first waterfall we reach a second fall showing:—

	FT.
Sandstone	4
Coal	1
Sandstone	7
Clay	3
Coal	2

About 100 yards above this fall there are old workings in another coal-crop. As far as the second fall the measures dip north at 28°, but in the remainder of the ravine the dip is south varying to south-east.

From an examination of the numerous small disturbances of this tract an impression is gained that they have no connection with the north-north-west system of faults. On the other hand, they not only agree approximately in direction with the great Neath Disturbance which runs along the valley close by, but are manifested chiefly in its neighbourhood. Though the Pennant tracts both to the north and south show no sign of similar deformation, it does not follow that the softer measures underlying them are not in the same condition as those exposed at the surface. It is noteworthy, moreover, that the productive measures, from the Upper Four-feet Seam down, appear to have been less disturbed than those above that seam. The Upper Four-feet, Eighteen-feet and Nine-feet Veins are said to have been free from faults under ground where folding is visible on the surface, though they turned up at a steep angle at their crop near Pwll-faron. As the plans of the old workings are not accessible the statement has not been verified.

Mounting the south-eastern slopes of Hir Fynydd, we gain the horizon of some massive sandstones which correspond to the rocks occurring below No. 2 Rhondda from Aberdare westwards (p. 52), and to those of the Maesteg neighbourhood where they have been described under the name of the Llynfi Rock.* They are associated with some thin coals, one of which, with a thickness of one foot ten inches to two feet, can be seen at the head of Clwydau Brook, and in a stream 400 yards to the east. This seam has been worked round the northern promontory of Hir Fynydd along the crop as shown on the map. More can be seen of these rocks and thin seams farther west (p. 69).

The outcrops of the Eighteen-feet and Nine-feet Veins have been trenched almost continuously across the mountain to Tir-bach, and the coals are frequently visible. A fault with a downthrow west of forty yards has been proved in the workings both of Maes-marchog and Onllwyn, and is commonly known as the Glyn Corwg Fault. In direction and position it favours this identification, but it cannot be traced continuously even so far as Pwll-faron. On its east side the Upper Four-feet crops out in a patch-work 500 yards west of Tir-bach, and a coal above it, two feet thick, is identified as the Stwrain.

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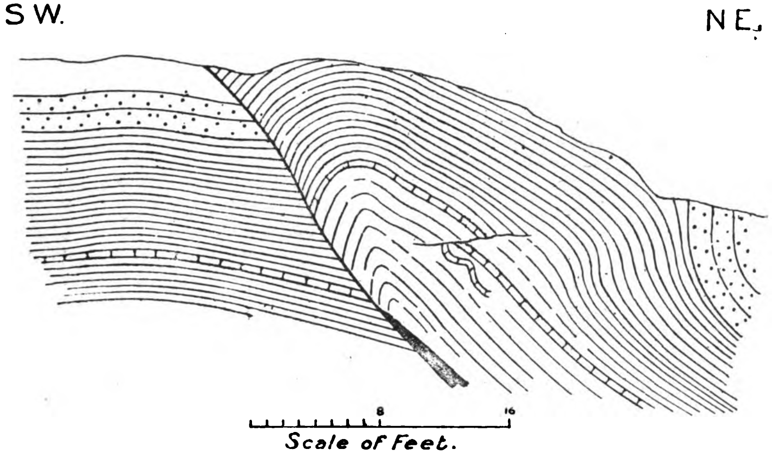
* The Country around Pontypridd and Maestêg (*Mem. Geol. Survey*), 1903, p. 30.

A sharp fold and overthrust fault is well exposed in the patchwork (Fig. 4). Though it displaces the Four-feet it was represented underground only by a tract of soft coal in the Eighteen-feet Vein, but it had the effect of bringing the two veins within a distance of five yards of one another, instead of the normal distance of eighteen yards. The similar occurrence noted on p. 63 may have been due to the same sort of deformation. The Eighteen-feet Vein proved to be seventeen to twenty-four feet in thickness, a fact which explains the ruinous condition of the ground where the coal was worked to the crop. A level eighty yards north of it was on the crop of the Cornish Vein, and another, 170 yards farther on, was on the crop of the Nine-feet Vein, while lastly, a level by the smithy was driven on the Yard, or, as it is here called, the Brass Vein.

FIG. 4.—*Overthrust in Coal Measures, Tir-bach.*

By A. STRAHAN.



The interesting section shown in Fig. 5 was temporarily open to view in the crop of the Nine-feet Vein in 1897. The strata showed the following sequence:—

Nine-feet Vein, Tir-bach.

	FT.	IN.
Shale and sandstone (*f*)	——	
Coal (*e*)	1	0
Stone and coal (*d*)	1	0
Shale (*c* and *b*)	4	0
Coal, seen to (*a*)	4	0

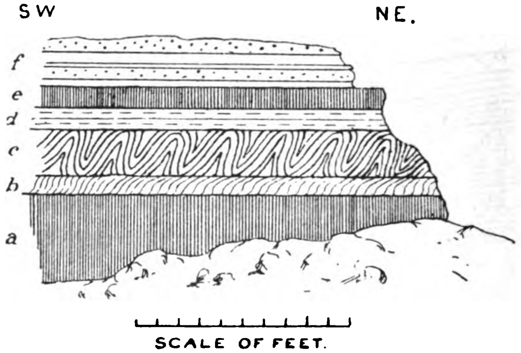
Though all the other beds were free from disturbance, the shale, four feet thick, was sharply contorted. The folds, which were inverted, ranged in a N.N.W. direction, indicating that they had been produced and pushed over by movement from the W.S.W. A few yards farther on the coal became schistose, so as to weather into plaquettes, with razor-like edges and slickensided on every surface and extremely brittle, as was the case near Hirwaun (p. 55).

Obviously the shale, acting as a lubricant, has permitted differential movement to take place between the strata above it and those below it.

At Coedcae, and again by the side of the tramway 500 yards to the north-west, the Bluers Vein has been worked for local use; at the latter spot the coal is said to be two feet three inches thick. Further east the crop can be traced continuously by means of old workings and a rock above it for nearly two miles, to a level at Ton-planwydd which shows the vein to be one foot eight inches to one foot ten inches thick. The Cnapiog Vein, with a reputed thickness of one foot four inches, crops out in a dingle 300 yards north-west of Ton-planwydd and again in a mine-patch south of the old Banwen Works. In a bend of the river close by, and south-west of Dysgwylfa, sandstone rests on upturned shale so as to simulate an unconformity, thus adding another to the many proofs of deformation of strata which this region furnishes.

FIG. 5.—*Contortion in parting between two Coals, Tir-bach.*

By A. STRAHAN.



The Henrhyd Fault, the effects of which are easily ascertained at the Henrhyd Waterfall, is lost to sight under the Boulder Clay near Colbren Junction. It evidently dies out, for there is no displacement apparent in the crops of the Nine-feet and Eighteen-feet Veins farther south, nor even in that of the Bluers Vein on Banwen Perddyn.

The Dulais Valley.

By A. STRAHAN.

At Onllwyn the Stwrain, the Four-feet, Eighteen-feet, Nine-feet and Brass Veins have been worked. The coals are more completely anthracitised than in the Vale of Neath, and the two last-named are used for malting purposes. The Big or Nine-feet Vein consists of solid coal six and a half to seven feet in thickness, and the Brass Vein of solid coal three feet in thickness. Pyrites occurs in both; in the Big Vein it takes the form of an irregular layer about two feet above the bottom of the vein, the layer consisting partly of a bright granular coal which is used as a fuel in the houses of the neighbourhood, and partly of black granular coaly pyrites; in the Brass Vein it occurs as an impersistent black layer lying nearer the top than the bottom of the vein, and generally showing thin seams or granules of yellow pyrites. The layer is sometimes absent for several hundred yards. The fuel in preparation for the maltster is passed over screens with bars three inches apart, and the pyrites is picked out. The commercial analysis shows 93·09 per cent. of carbon and an absolute freedom from arsenical sulphur in the fuel thus prepared.

The sequence of measures above the Brass Vein as proved at Onllwyn was given by Mr. David Davies, Manager of the Onllwyn Colliery, as below; the measurements below the Brass Vein are quoted from an old section preserved at the colliery.

Onllwyn.	YDS.	FT.	IN.
Four-Feet Vein	——		
Measures	20	0	0
Eighteen-Feet Vein	——		
Measures	14	0	0
Cornish Vein, with 4 inches of "cornish" on top	——		
Measures	13	0	0
Harnlo Vein	——		
Measures	11	0	0
Big or Nine-Feet Vein, 6 ft. 6 ins. to	2	1	0
Measures	20	0	0
Brass Vein	1	0	0
Measures	21	0	0
Two-Feet Vein	0	2	0
Measures	17	0	3
Bluers Vein	1	0	9
Measures	12	1	9
Rhyd Vein	0	2	3
Measures	6	1	6
Grey Vein	0	2	6
Measures with Yellow and Black Pins, Ribbing, Llyfrau and Little Blue Vein of ironstone	——		

The old section referred to also gives the following thicknesses of coal-seams:—

	FT.	IN.
Pennies Seam (25 feet above the Stwrain)	0	6
Stwrain Seam (considered to be the Two-Feet-Nine Seam of Aberdare)	2	6
Four-feet Seam	4	6
Eighteen-feet Seam	11	6
Cornish Seam	3	10
Harnlo Seam	2	6
Nine-feet Seam	6	0

The coals are worked by a slope driven in below the crop of the Eighteen-feet Vein. Two faults have been proved in the workings. The more eastern, which is supposed to run across the mountain to Aberpergwm and to be the Glyn Corwg Fault, is a downthrow west of forty yards. It may be described as a synclinal fault inasmuch as the measures on its east side (Maes-marchog) dip south-westwards, whereas those on its west side (Onllwyn) dip S. 16° E., though with an inclination of only about two or three inches to the yard.

Nothing definite is known about the fault either to the north or south of the workings of the two collieries named. The second fault is a sharp roll as much as a fracture, and throws the beds down sixteen yards eastwards. It passes almost under the Chapel, and is known as the Chapel Fault. Between these two there is some little overthrusting visible in the crop of the Four-feet Vein in a patch 400 yards E.S.E. of the Onllwyn slope, but elsewhere the crops are regular; the Eighteen-feet crops under the Ventilating Fan, and the Nine-feet in the cellars of the Halfway Public House and in a patch to the north of it, while the Brass Vein has been worked at a point 300 yards north-east of the Public House.

To the west of the Chapel Fault the Big or Nine-feet Vein is just "out" on the north side of the railway, and some trial-pits reached the Brass Vein at twenty and twenty-one yards depth. The Big Vein, however, catches the upper slope of the hill along the east side of the Pwllau-bach Fault, about to be described. The Brass Vein has been got close to its crop in levels in Cwm-mawr and some holes on the mountain 150 yards to the east are supposed to be in the crop. The Eighteen-feet Vein crops under the school, and the Four-feet Vein is visible in a patch at the Rhyd-y-pwllau. A section of the measures proved in the Drum (or Drym or Drim) Colliery is given in *Vertical Sections*, Sheet 85, Section No. 15. According to it the Gwythien-fach or Llyfrau Mine lies twenty-one and a half yards, the Las-fach Mine thirty yards, and the Cnapiog (Knobby) Mine thirty-eight yards, below the Grey Vein of the section given on p. 67.

The Pwllau-bach Fault runs under Rhyd-y-pwllau and across Drum mountain to Abercraf. Southwards its effects are obvious where it throws down the Pennant on either side of the plateau of Hir Fynydd, and it is visible also in a stream fifty yards south of the railway. On Drum mountain it is a downthrow west of eighty yards, as proved by the fact that it brings the Nine-feet Seam on its east side against some mine-ground which is identified as the Black Pins on its west side. The evidence for its existence at Abercraf is given on p. 71.

Assisted by the Pwllau-bach Fault and others, and by the southerly dip, the coals which crop out at Onllwyn gain a considerable depth at Seven Sisters. The White Vein, which lies seventy-two yards above the Nine-feet, has been proved at a depth of eighty yards at Nant-melyn-uchaf, while at the Seven Sisters Colliery the Brass Vein was reached at 208 yards (*Vertical Sections*, Sheet 85, No. 16). At this colliery the Upper Four-feet, the Big (or Nine-feet) and the Brass Vein are worked, and of these the Big Vein is used for malting. The Big Vein consists of:—

Big Vein, Seven Sisters Colliery.

	Ft.	In.
Top Coal, not worked	2	0
Parting of dirt	0	0½
Middle coal	3	6
Bottom coal	3	6

The top coal is interbedded with layers of black stone and is not worked with the rest of the seam. Pyrites occurs in the form of dull black layers about one and a half to two feet above the bottom of the bottom coal. Coal for malting is passed over bars two inches apart, and hand-picked. The Brass Vein lies twenty yards below, and consists of three inches of top coal, two inches of parting, and two feet six inches of bottom coal.

The dip is slightly east of south at three inches to the yard, and two westerly downthrows have been proved, one of five yards, and the other of twenty yards; neither can be detected in the Pennant scarp to the south.

This, so far as the Dulais Valley is concerned, is the last colliery in which the lower seams are being worked, and we may now retrace our steps and note the outcrops (below the Ynysarwed Vein) which follow the Pennant scarp. On the east side of the Pwllau-bach Fault two seams have been worked for local use, the upper one on either side of Sarn Helen east of Bryn-y-garn, the lower one in levels 170 yards south-east of Bryn-y-garn and 450 yards north-north-east of that farm respectively. Both appear to reach a thickness of two feet in places, but perhaps would hardly average that amount of workable coal. Two-thirds of a mile south-west of Bryn-y-garn there are old holes in what appears to have been a coal interbedded with much shale, but in a steep sided recess in the escarpment north of Carn Cornel two seams are well seen. Their exposure is due to some artificial gutters having been deepened by rain into imposing ravines, and they show, respectively, thirteen inches of coal and twelve inches with the base not seen, separated by thirty-three feet of shale. The lower of these is considered to represent the Pant-rhyd-y-dwr Vein, and, descending the hill over three beds of sandstone, we find a crop 170 yards north-east of Llwyn-goleu of what is identified as the Pinchin Vein, both of which names are derived from the district of Ystalyfera (Sheet 230).

Lower down in this same recess the Red Vein, which proves a constant and valuable seam for some miles westwards, first comes into prominence. It approaches an anthracite in composition, and has been worked around Bryn-teg, where it shows in an old level three feet of coal under a shale-roof. On the other side of the recess it is got by the slope of the Dillwyn Colliery. The dip is about S.S.W. at four inches to the yard and the coal crops a few yards below the mouth of the slope. A fault with a downthrow west of two yards was proved under Nant-y-cafn-isaf, but found to die out southwards, and a downthrow east of thirteen yards was proved south-east of Bryn-teg. Several attempts have been made to find the Red Vein between the Bryn-teg and Dillwyn workings, but for some time without success. A trial shaft proved a coal, and a drift was commenced which proved a coal sixteen inches thick, with shale above and below it. This was thought not to be the Red Vein, and a boring was put down for a further thirty-seven feet, without, however, proving any coal. Subsequently a second shaft was sunk, the following section of which has been supplied by Mr. Morgan W. Davies :—

Shaft at Bryn-teg sunk in 1903.

	YDS.	FT.	IN.
Clay (Boulder Clay)	4	1	0
Coal, the seam proved in the former trial	0	1	0
Clay and boulders	10	0	0
Rock and clift	22	2	7
Rock	0	0	1½
Coal	0	0	1½
Fireclay	0	2	4
Dark sandstone	3	0	6
Rock and clift	9	2	4
Bast	0	0	8
Coal, Red Vein	0	2	6
Fireclay	1	1	7
	53	2	9

A white quartz-grit, resembling Cockshot, with eight inches of coal on top of it, crops out in, and just above, the railway west of Bryn-teg; the rock is said to lie some forty yards below the Red Vein, but does not appear to have been traversed by the shaft. Another hard grit crops out just below the old level at Bryn-teg. The lower rock is said to lie just below the Red Vein clay, a bed of noted quality and seven to nine feet thick. The Pinchin Vein crops out about ninety yards south of the Dillwyn Slope, while an old incline up to the Ynysarwed Vein leads us over the crops of the sandstones which were noted above Llwyn-goleu. The Pant-rhyd-y-dwr Vein and another below appear to have been tried without much success. The thickness of measures between the Red and Ynysarwed Veins amounts here to about 270 yards, the distance being made up as follows :—

Near Carn Cornel, Hir Fynydd.

		YDS.
Ynysarwed Vein to Pant-rhyd-y-dwr Vein	about	33
Pant-rhyd-y-dwr Vein to Pinchin Vein	„	183
Pinchin Vein to Red Vein	„	53

The rock-beds referred to slant gently down to Crynant. One in particular below the Pant-rhyd-y-dwr Vein is repeatedly in sight along the east side of the railway, while the seam itself can be located in the Coed-du ravine. Here all are cut off by the Crynant Fault described on p. 77.

The Red Vein is believed to cross the Dulais at Ynys-fforch-fach and to slant thence through some swampy ground to some old crop-workings north and north-east of Henllan. A trial, however, 100 yards north of Ynys-fforch-fawr and about 220 yards south of the supposed crop, failed to find the seam. This fact and the patchy way in which the coal has been worked at the crop suggest that the seam is impersistent; the last workings upon it (east of the Crynant Fault) occur 500 yards N.N.W. of Henllan.

The Tawe Valley.

By A. STRAHAN.

The outcrops of the lower veins, which we have traced as far as Onllwyn (p. 68) run along the south side of the Tawe Valley to Ynysbadafau. The crop of the Brass Vein, however, though it has been found in a slope on the east side of the Pwllau-bach Fault near Abercraf, is unknown from that point to the old working near Onllwyn already mentioned, and a doubt as to the effects of the Chapel Fault makes its position still more uncertain. The Cnapiog Seam is visible in the side of the railway north of the slope mentioned, and must run thence along the steep southern bank of Nant Llech, some mine-ground which has been worked to the south of the railway having been identified as the measures overlying the seam. Nant Llech itself is a gorge in shale and mudstone, sometimes rich in plant-remains, which lie between the Cnapiog Vein and the Farewell Rock. These beds yielded a number of tree-trunks which are now preserved at the Royal Institution, Swansea.

The Pwllau-bach Fault is well shown in a stream 300 to 500 yards south of the railway. The measures dip steeply towards it on its east side, as may be seen both in the workings of the Brass Vein and on the surface. On its west side there is an old quarry and patch just below which the White Vein crops out. The Four-feet Vein has been opened in a slope at the Abercraf Colliery and also has been worked up to the fault, and the Big Vein is being worked by a slope on the crop ninety yards south of the railway. The Brass Vein crops about ten yards below (north of) the railway, and in a ravine leading down northwards the Trigloin can be fixed, with the Cnapiog and its overlying rock 100 yards north of it. Thence downwards the ravine shows shale, presumably the Nant Llech measures, while the Farewell Rock comes up in the north bank of the Tawe. The crop of the Big Vein runs thence by the mouth of the slope of the International Colliery, forty yards above the slope of Hodgen's Colliery, which is in the Brass Vein, to the railway above Gwaun-y-clawdd where the coal is visible. There, owing to a roll which changes the southerly dip to south-west, it strikes down the hill to an old level 200 yards east of Little London. The Cnapiog is said to crop under Gwaun-y-clawdd, and may be the seam visible in a much disturbed river-section near the Lamb and Flag Inn, as noted later on. The Four-feet runs parallel to the Big Vein, but 80 to 100 yards south of it, and has been worked for some three hundred yards south of Little London, when it became faulty. It is said to have been found near the Bridge at the Castle Inn, while what may be the White Vein crops east of Gwaun-ton. The hillside below Gwaun-ton has been riddled with old patches and levels for mine. The Brass Vein, according to Mr. M. W. Davies, yields the following sections:—

	Abercraf.		*Hodgen's Colliery*	
	FT.	IN.	FT.	IN.
Cliff roof	—		—	
Clod, 6 ins. to - - - - -	2	0	0	4

	Abercraf. Ft.	*Abercraf.* In.	*Hodgen's Colliery.* Ft.	*Hodgen's Colliery.* In.
Coal	0	6	0	5
Clod	0	3	0	4
Coal	2	7	2	9

and the Four-feet Vein at Abercraf shows five inches of clod on three feet six inches of coal. A general section of the measures is furnished by the same authority as follows :—

	Abercraf. Thickness. Ft.	In.	Depth below Penny Pieces Mine. Yds.	Ft.	In.
Penny Pieces Mine	—		—		
Stwrain Vein	1	7	13	1	7
White Vein	3	2	28	1	9
Coal (the Eighteen-feet Vein of Aberpergwm)	2	9	46	0	6
Four-feet Vein	3	8	60	1	2
Two-feet Vein	2	4	75	1	6
Big or Nine-feet Vein	9	0	107	2	6
Brass or Peacock Vein	3	1	128	2	7
Coal (the Trigloin Vein of Cwmamman)	1	8	147	1	3
Coal	2	6	166	0	9
Coal	2	0	175	2	9

Where the crops traced above reach the Tawe they enter ground about which little is known further than that it is highly disturbed. At a bend in the river 100 yards below the Lamb and Flag Inn the strata are vertical and even inverted for a few yards, but a coal two feet thick which crops here appears to be the Cnapiog, and to be not far out of its place relatively to the Farewell Rock on the one side and the Brass and Big Veins on the other. Following the river down we pass an old level close to the Castle Inn, said to have been in the Big Vein, and another about 200 yards below the inn in the Four-feet Vein. Thence downwards to Penrhos we cross strata dipping steadily south-eastwards at 20° to 45° and to all appearance lying above the Four-feet Vein.

That vein, however, has been worked and proved to crop at an old level in Nant Penrhos some distance up the south-east side of the valley, and has been proved thence almost continuously to a slope near the Ystradgynlais Colliery. Clearly, therefore, there must be a large downthrow north between this crop and the one near the Castle Inn. The downthrow is generally known as the Cwm-ddu Fault, and though the information concerning it lacks definiteness, there is reason to think that it passes through Penrhos, some 150 yards within the mouth of the Cwm-ddu Level, through or close to the shaft of the Hendre-ladis Colliery, and along Nant Gyrlais to Ystrad-fawr. In the first place, the Cwm-ddu Level, which commences by the side of the river north-west of Penrhos, intersected the Big Vein 300 yards south of Penrhos, above the position that would have been assigned to that vein from a consideration of its crop and inclination at the Castle Inn. In the second place, the Penny Pieces mine-ground, hich lies about forty yards above the White Vein and about seventy-two yards above the Four-feet, is said to have been recognised in Nant Gyrlais.* There must, therefore, be a northerly downthrow between this crop and that of the Four-feet, with a shift of not less than 150 yards.

On the south-east side of the Cwm-ddu Fault the following facts prove a fairly regular run of the strata. The Balance Pit at Hendreladis, on the west side of the railway, proved the Four-feet at seventy-two yards depth.† An old pit on the east side of the railway proved the Stwrain at twenty-nine yards, the White at forty-four yards, the Black at fifty-one yards and the Four-feet Vein at seventy-five yards depth. Further south the Ystradgynlais Colliery proved the Stwrain at eighteen yards, the White at thirty-one yards, the Black at thirty-eight yards, and the Four-feet Vein at sixty-three yards (*Vertical Sections*, Sheet 85, No. 19). It appears, therefore, that these three pits along the railway are not far out of the line of level course, as might have been inferred from observations on the surface. The crops of the seams run in accordance with these figures. The Four-feet Vein comes to the surface 300 yards north of Ystradgynlais Pit, and the Brass Vein 500 yards west of the pit.

On the north-west side of the Cwm-ddu Fault but little is known until we reach a second and parallel northerly downthrow, presently to be described. If the Penny Pieces were correctly identified the Four-feet should be there, and as a fact that vein is stated to crop in the Tawe close to Ystradgynlais Rectory and the White Vein to crop under the Church. It would seem likely, however, that the ground between the two faults is much disturbed, so far as can be judged from its appearance in the river north-west of Penrhos.

The second downthrow referred to was reached in the Four-feet workings from Giedd,‡ about 150 yards south-east of the Tawe at Ystradgynlais. The effect is to throw in the Black, White, Four-feet, Big (presumably) and the Brass Veins a third time. They all crop in the Giedd, the Black and White Veins rising to the surface under the canal-bridge; they are said to have been seen in the Tawe also, above the Giedd. The Four-feet was worked under the river to the fault as above mentioned and has been recently opened in a slope about 600 yards further down the canal.

This fault not improbably crosses the Tawe at a point 350 yards north-west of Cwm-ddu level, where the strata are nearly vertical. Thence it may be supposed to run along the west side of the Tawe and to cut off what we may call the Abercraf range of coals, for though the Big Vein is said to have been proved in a level west of the Castle Inn, no work seems to have been done upon it, while neither this nor any of the other veins have been found further west; in fact, the direction of level course would carry them to the Giedd north of some old workings in the lowest mine-ground. Still pursuing the same direction, the fault traverses some swampy featureless ground in which the Farewell Rock might have been expected to crop out, and finally will serve to account for the appearance of a small inlier of limestone at Garth described on p. 36. Here it probably passes into an anticline.

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* I am indebted to Mr. Thomas Lloyd for this and much other information concerning the neighbourhood of Ystradgynlais.

† The new pit of the colliery, about 400 yards further west, reached the Four-feet at 32 yards, and the Nine-feet Vein at 92 yards depth, but was sunk in highly-inclined strata, close, as it is believed, to the Cwm-ddu Fault.

‡ For the information concerning this fault I am indebted to Mr. E. R. Fisher.

These two faults explain the main features of the structure of the region, but there are doubtless other complications. It is not obvious, for example, why the coals which crop near Gwaun-y-clawdd with a southerly dip do not reach a greater depth near Hendre-ladis. It would seem that there must be a syncline between the two, of which in fact there is some evidence in some gentle and variable dips observable near Gwaun-ton. The contortion shewn in the river-bank at the Lamb and Flag Inn, moreover, does not range in the direction of the greater faults, but more nearly east and west, as though it were a branch from one of them. Again the distances between the outcrops of the main coals and the lower courses of mine-ground are sometimes too small, as though there had been overthrusting.

Though the precise position of these dislocations is so difficult to determine their general direction is beyond doubt; they are parallel to, and point directly for, the main axis of the Cribarth Disturbance, and therefore run almost at right angles to the normal north-north-westerly faults. Bearing in mind the general character of the Cribarth and Neath Disturbances as belts of compression we may safely assume that these dislocations have nothing in common with the normal faulting. More probably they are overthrusts, and the extreme difficulty of determining their position and numbers is likely to be due to their ramifying and meandering after the habit of overthrust faults, and to the displacement being generally effected along a number of planes of movement, rather than along one clean fracture.

Much mine has been raised from the measures next above the principal coals, and the old shale-tips are so large as to yield springs which have been utilised as a source of domestic water-supply. The Penny Pieces yielded the following section at an old level 600 yards east of Penrhos, according to information furnished by Mr. F. H. Bell :—

	FT.	IN.
Rock-roof	3	0
Rock-pin	0	3
Shale	2	6
White pin	0	2
Double pin	0	4
Shale with balls	8	0
Mine	0	3
Shale	11	0
Coal	1	0

At the Ynyscedwyn (Hendre-ladis) Colliery the Big and the Brass Veins are both worked, and the latter is used for malting. The Brass

Vein contains a band from one to three inches thick of finely granular coal traversed by threads of pyrites; small lumps of pyrites also occur, but extremely rarely. The coal varies from two feet ten inches to three feet eleven inches in thickness, and the granular band is picked out as far as possible from fuel intended for the maltster. The Big Vein contains a band of pyrites about ten or fifteen inches above its base. Yellow pyrites occurs also in lumps but to a very small extent.

At the Ystradgynlais Colliery the White Vein has been tried, but the Black, Four-feet, Big, and Brass Veins, extensively worked. The measures below the Four-feet Vein were not proved in the shaft-section (*Vertical Sections*, Sheet 85, No. 19) but were given by Mr. T. Lloyd, the manager, as follows:—

Ystradgynlais Colliery.

	YDS.	FT.	IN.
Four-feet Vein		—	
Measures	15	0	0
Harnlo Vein	0	2	6
Measures	25	0	0
Big or Nine-feet Vein		—	
Measures, 18 yds. to	20	0	0
Brass Vein		—	

On the top of the Harnlo there lies about one foot three inches of "cornish," and thin veins of this material occur in the coal also, sometimes in sufficient quantity to spoil it. Though having the fracture and somewhat the appearance of cannel the "cornish" yields no gas and contains much ash. At Aberpergwm the "cornish" was associated with the Four-feet Vein (p. 62).

THE PENNANT SERIES.

East of the Neath.

By W. GIBSON.

A long and narrow plateau of Pennant sandstone forms the top of Mynydd Cilfach-yr-encil. No. 2 Rhondda has been worked by levels beneath it, and averages over two feet in thickness. On the west side of the Taff the position of the seam is vague owing to the fact that the coal is too thin to be worked at a profit and also to the unusually feeble character of the sandstone-feature above it. The Pennant tableland of the central portion of the coalfield rises northwards into a high plateau with a height of 1,969 feet near Carn Mosyn on Cefn ffordd. No. 2 Rhondda has proved of remunerative thickness on Mynydd Resolven only, where it exceeds two feet. East of the Glyn Corwg Fault it is thin, but its position, in spite of its being thrown 900 yards to the south by the fault, can be determined by a characteristic crag of Pennant above it. The crag accompanies the outcrop of the seam as far as Llyn-fawr, but there some grits below the coal form the main escarpment and the outcrop of the seam becomes indistinguishable upon the featureless moorland above.

The following section of No. 1 Rhondda was obtained at the waterfalls at the head of the Rhondda valley.

In the Rhondda-fawr.

		FT.	IN.
No. 1 Rhondda Seam.	Sandstone forming the roof	—	
	Coal	0	1
	Ironstone	0	2
	Coal	0	4
	Clod	1	0
	Coal	0	8

Under Resolven Mountain No. 1 Rhondda is of unusual thickness. In an old level 600 yards west of the trigonometrical station on the summit of the mountain the seam is made up of four feet of coal with a two-inch shale-parting. Much coal has been won from this and other levels and also from the levels of the Cwm Clydach collieries in Cwm Clydach.

The roof is generally a black shale with a few ironstone nodules containing *Entomostraca* and *Anthracomya Phillipsi*. The latter fossil is abundant and well preserved in some black shales visible in an old level at Blaen-cam-goed near the head of Cwm Clydach (see also p. 78). In North Staffordshire it indicates a comparatively high horizon in the Coal Measures, being most abundant in the basal subdivision of the group succeeding the Middle Coal Measures, while it is scarce in the Middle and unknown in the Lower Coal Measures.

West of the Neath.

By A. STRAHAN.

The No. 2 Rhondda Seam, here known as the Ynysarwed Vein, slants up from the alluvial flat through the wood of the same name to the ravine of Garwed Brook. A great sandstone above it gives a precipitous character to the ravine and a series of old levels marks the outcrop of the coal below. In the ravine, but not elsewhere, the Pant-rhyd-y-dwr Vein also has been worked, and a rider eight inches thick is visible in the brook. A second line of levels about eighty yards above the Ynysarwed has been opened on the No. 1 Rhondda Seam, here known as the Pen-y-graig Vein, but this appears to become too thin to work before reaching the ravine, though a level 400 yards beyond the ravine shows coals one foot four inches and one foot thick respectively, with six inches of clay between. North of this the crop becomes untraceable.

The Ynysarwed Vein, however, runs on and has been dug for use in the farms near Blaen-nant-yr-hebog, where a level shows three feet of coal. A second coal, with a shale-roof, comes in below the Ynysarwed here, as is proved by a level 500 yards north of the farm named. The Ynysarwed is distinguished by the massive rock which often lies directly upon the coal, and by a conglomeratic band which lies two or three yards above the coal; thus a dingle south of Graig-lwyd-fechan shows:—

Ynysarwed Vein, Vale of Neath.

	FT.	IN.
Sandstone	—	
Conglomerate containing pebbles of quartz and ironstone	3	0
Sandstone	3	0
Ferruginous shale	6 ft. to 8	0
Coal, seen to	1	6

Under the Graig-lwyd-fechan the coal is seen to a thickness of two feet ten inches under the sandstone, and again to two feet thickness in a waterfall east of the crag.

A stream down the face of Graig-lwyd crosses the Pwllau-bach Fault, and within a few yards of it shows one foot six inches of coal resting on twelve feet of clod, and overlain at a height of four to six feet by the usual conglomeratic band. Round the north and east sides of the plateau the crop is traceable only by means of the rock above it, but there is an old level upon it one mile north of Crynant, while it has been much worked at the Crynant and Maes-mawr Collieries. The vein here is two feet ten inches thick and is underlain at a distance of twenty-one yards by the Pant-rhyd-y-dwr Vein, and overlain by the usual massive rock and conglomeratic band. The dip is south, varying to south-west, and the coal has been worked southwards as far as the Crynant Brook and eastwards to an irregular fault, or crush with overthrusting, which runs in a general north-north-easterly direction 300 yards east of Gelli-ben-uchel. Westwards the workings have been limited by a fault with a downthrow west of twenty-one yards, which is supposed to run to Wern Plemys (Sheet 230), but the course of which north of Crynant is conjectural. The coal is said to be intermediate between a steam-coal and an anthracite. No. 1 Rhondda also proves here and has been worked by level 800 yards south-east of Crynant Station. The section is reported to have shewn coal two feet, and bottom coal nine to ten inches, with sixteen to thirty inches of clay between. The Crynant Fault stopped the westward workings close to the level.

Southwards the Crynant Fault can be traced across the outcrops of some unimportant veins in the Pennant. Of these the first above No. 1 Rhondda is known as the Dirty Vein; it has been worked for local use to the west of the Garwed Brook. Above this and forming a small outlier on the crest of the hill is the Beacon Vein, which is supposed to be the Clay Vein of Aberdulais. The fault passes close by the outlier and on its west, or downthrow, side both these veins can be identified, the Dirty Vein 300 yards south-east of Tir-lan, where it is said to be one foot eight inches thick, and the Beacon Vein 400 yards further on in the same direction. The following are approximate measurements of these strata between Crynant and Resolven:—

	YDS.
Beacon Vein to Dirty Vein	43
Dirty Vein to No. 1 Rhondda or Pen-y-graig Vein	147
No. 1 Rhondda to No. 2 Rhondda or Ynysarwed Vein	75
No. 2 Rhondda to Rhyd-pant-y-dwr Vein	21

Fossils.

The following fossils have been obtained from strata close above or below the seams named, and have been identified by Mr. E. T. Newton, F.R.S., and Dr. F. L. Kitchin.

No. 1 Rhondda Seam.

Anthracomya Phillipsi, *Will.*	Ty'n-y-cwm Brook, 2¼ miles east of Resolven Station.
,, ,,	Tip N.E. of Pant-y-geifr Farm, 1¾ mile E.N.E. of Resolven Station.
,, sp.	Tip S.W. of Pant-y-geifr Farm.

No. 2 Rhondda Seam.

Insect Wings	Tip on 600-foot contour-line, 1¾ mile N.E. of Resolven Station.
Anthracomya Phillipsi ? *Will.*	Do. Do.

This *Anthracomya* has not been noticed elsewhere in No. 1 or No. 2 Rhondda, but on the other hand, a shell comparable with it occurs in the Mynyddislwyn Vein of Monmouthshire in fair abundance. No. 2 Rhondda occurs at the bottom, and the Mynyddislwyn Vein at the top of the Pennant Series. The following fossils have been obtained from localities in Sheet 249, since the publication of the memoir on that sheet.* Some of them are recorded in that memoir (p. 64) from an ironstone about twenty-seven yards above the Mynyddislwyn Vein.

From strata associated with the Mynyddislwyn Vein.

Ostracoda.	Old Gelligaer Colliery, Llancaiach.
Leaia Leidyi, *Lea*, var. salteriana, *Jones.*	Old Gelligaer Colliery, Llancaiach.
Crustacean.	Libanus Colliery, near Tredegar Junction.
do. , *gen. nov.* ?	Gwernau Level, Maes-y-cwmmer.
Prestwichia cf. rotundata, *H. Woodw.*	Gellideg and Gwernau Levels, Maes-y-cwmmer.
do. cf. scheeleana, *Ebert*	Gellideg Level.
do. sp.	Old Gelligaer Colliery.
Orthopterous Insect Wings.	Gwernau and Gellideg Levels.
Anthracomya cf. Phillipsi, *Will.*	Old Colliery, Top Hill, Llancaiach; Top Hill Level; Old Gelligaer Colliery.
Posidonomya ?	Old Gelligaer Colliery.
Diplodus gibbosus, *Ag.*	Gellideg Level.

Many plants also have been collected from this and other parts of the Coal Field, and are undergoing examination by Mr. Kidston.

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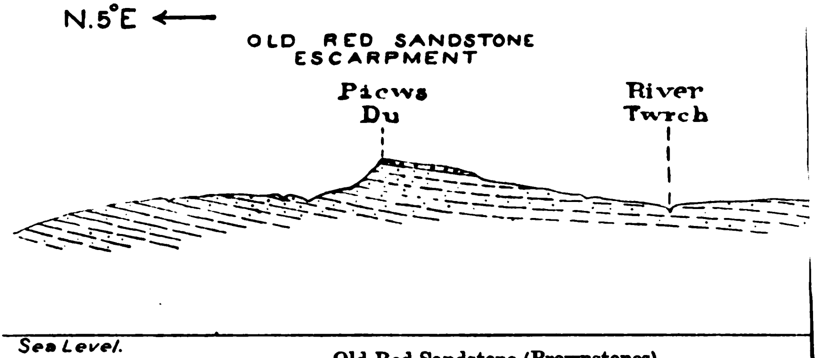
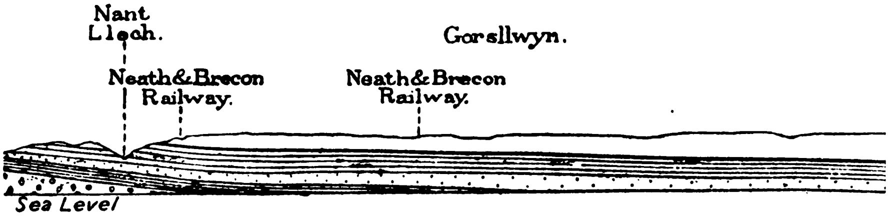
* Geology of the Country around Newport (*Mem. Geol. Survey*), 1899.

GEOLOGY OF MERTHYR TYDFIL.



Old Red Sandstone (Brownstones).



Lower Coal Series over Farewell Rock
and Millstone Grit Shales.

CHAPTER VI.

FAULTS AND DISTURBANCES.

Introduction.

By A. Strahan.

Of all the structural features of the Coal Field few present more points of interest than the two illustrated in this Sheet which we have named the Neath and the Cribarth Disturbances. The Neath Disturbance was the first to be encountered, as the surveying was carried westwards, of what has proved to be a series of belts of compression and overthrusting, which there is not only reason to think are the latest of the movements to which the strata have been subjected, but which have determined the river-system and, indirectly, the physical features of the whole region.*

The Neath Disturbance was first detected in the western edge of Sheet 232. It enters the Sheet under description at Bryniau Gleision and thence runs across the map in an almost straight line with a direction W. 24° S., finally ending in the neighbourhood of Neath (Sheet 247) after a course of about 24 miles. The Cribarth Disturbance commences in Blaen Senni in the Old Red area and passes between Fan Gihirych and Fan Fraith, where it introduces a minute outlier of the Carboniferous Limestone Series, but it best displays its effects in the grand folds of limestone and Millstone Grit on Cribarth. Thence it passes down the valley of the Tawe, causing the overthrusting and repetition of the outcrops of the lower coals described on p. 73, and ends near Swansea (Sheet 247) after a course of about 20 miles in a general direction W. 38° S. The Cribarth Disturbance is succeeded by others of a similar character further to the north-west, and finally by the great uplift which brings Ordovician rocks to the surface near Llandilo, as will be described in the memoir explanatory of Sheet 230.

Intense as has been the movement within these narrow belts of folding, the strata of the intervening areas show but little disturbance, the giving way of the rocks along the belts having sufficed to relieve the strain. So far as the area under description is concerned the disturbed belts average about half a mile in width and lie about 7 miles apart.

Not only in their direction but in their detailed structure, these west-south-west disturbances contrast strongly with the north-north-westerly faults. They may be described generally as consisting of sharp synclinal and anticlinal folds, no one of which persists far, but which by reappearing along the same line give a disturbance of great persistence. Normal faulting is the exception, while on the other hand there is frequent evidence of overthrusting, the plication itself also being proof that the movement was one of compression. The north-north-westerly faults on the contrary are usually clean-cut fractures, succeeding one another at frequent intervals, while the fact that they are normal, that is that they hade to the downthrow, proves that they resulted from an expanding movement.

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* *Quart. Journ. Geol. Soc.*, vol. lviii., p. 207 (1902).

The Neath and Cribarth Disturbances are the first two of the series. They are succeeded towards the north-west at more frequent intervals by others of greater intensity. It may be inferred, therefore, that the impulse to which the pressure was due proceeded from that direction. In this respect they differ from the east and west folds which are developed in South Glamorganshire and which increase in intensity towards the south. They may belong moreover to a later date. The east and west folds have been shown elsewhere to have been produced in pre-Triassic times;* that the Neath and allied disturbances on the other hand were active at a later period would provide an explanation of their close connection with the river-system.

Of the north-north-westerly faults, the Dowlais, the Merthyr Church, the Glyn Corwg, the Pen-y-castell, and the Pwllau-bach Faults are the principal. All of these are downthrows to the west. It will be noticed that there is not one undoubted case of a fault belonging to this system crossing a disturbance of the Neath and Cribarth system, while on the other hand there are several cases where faults stop short at the disturbance.

In giving a detailed account of these various dislocations it will be convenient to confine ourselves firstly to those of the north-north-west system, commencing with the eastern part of the area under description.

NORTH-NORTH-WESTERLY FAULTS.

South of the Neath Disturbance.

By W. GIBSON.

The Dowlais Fault commences near Pengam (Sheet 249), and enters this map near the Pen-y-daren pits, where it has been proved in the workings of the Upper Four-feet Seam to have a downthrow of 45 yards to the west. In the patchworks south of Dowlais it brings the Upper Four-feet nearly on a line with the Ras Las Seam, and to the north of Dowlais it throws the lower portion of the Lower Coal Series against the middle sub-division of the Millstone Grit. Its influence is conspicuous to the east of Morlais Castle where it throws down the basal conglomerate of the Millstone Grit over 200 feet vertically below the limestone which forms the top of

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* The Country around Cardiff (*Mem. Geol. Survey*), 1902, p. 2, etc.

Morlais Hill. At Aberglas near Pont Garn its position in the limestone is indicated by a dip of 28° and a vein of calcite. Further north it appears to be dying out, for it scarcely breaks the continuity of outcrop of the basal bed of limestone. On the featureless plateau of Old Red Sandstone all trace of it is lost, nor is there anything to indicate that it crosses the line of the Neath Disturbance.

The Merthyr Church Fault dislocates the Pennant scarp to the south-east of Troed-y-rhiw, but is largely concealed by landslip. North of that place it is not seen at the surface, but it roughly coincides with the edge of the alluvium. In the workings of the Four-feet Seam of the Dyffryn pits it takes the form of two step-faults of 10 yards and 30 yards down west. Following thence the northern bank of the Taff it can be seen at the bend of the river near Cyfarthfa ironworks and again near an old limestone-quarry at the south end of Cefn Cemetery. There it can be estimated to possess a throw of approximately 30 yards, but it cannot be traced farther north.

The Werfa Fault shifts the outcrop of No. 2 Rhondda on Cefn Pennar for a horizontal distance of no less than 800 yards, not so much in consequence of its throw being large as from the fact that the slope of the ground closely approximates the angle of dip. It is indeed likely that the fault is on the point of dying out and that it is replaced by another fault of forty yards down west, which has been proved in the Bute Vein and of which the surface position lies 700 yards farther to the west. A long curved but nearly vertical face of the fault proved in the Bute Vein forms a cliff to the east of Werfa Farm. Farther north the line of fault is shown by the westerly displacement of some grit-bands on Twyn Ddysgwylfa; and still farther on by the displacement of the Farewell Rock and quartz-conglomerate of the Millstone Grit. In addition, on Oen Llwyn and Mynydd y Glog, several smaller faults interrupt the outcrop of the quartz-conglomerate, but none of them can be traced across nor even up to the Neath Disturbance. A fault of fifty yards down east proved in the Bute Vein east of Blaen-nant-y-groes is not recognisable above ground, and is probably cut out by the forty-yard fault before it reaches the surface.

The two Hirwaun Faults, both large downthrows to the south-west, are proved in the mine-ground south of Hirwaun. The one, to the east of Crawshay's Tower, is known as No. 1 Hirwaun Fault, and has a vertical displacement of 60 yards; the other, to the west of the tower, is known as No. 2 Hirwaun Fault, and has a throw of fifty yards. The latter is visible in Craig y Bwlch, and is no doubt continued farther to the south, though it cannot be traced on the featureless slopes of Mynydd Bwllfa.

The great Glyn Corwg Fault, where it emerges from the Pennant plateau on the south side of the Neath, greatly modifies the scenery. Thus the crags of Pennant sandstone, so conspicuous on Graig-isaf, terminate abruptly at the head of Cwm yr Argoed, to appear again half a mile to the north; similarly the features caused by the grits below No. 2 Rhondda, on the south side of the Vale of

Neath, are cut off sharply to the west of Cwm yr Argoed. An estimate of the vertical displacement of the fault will depend upon a more precise knowledge of the northerly rise of the strata than we possess. In Graig-isaf, on the east side of the fault, No. 2 Rhondda crops along the 1,500-feet contour; about half a mile to the north-west in the direction of rise, and on the west side of the fault, it crops on the 950-feet contour. The throw of the fault must therefore amount to 550 feet in addition to the amount the seam rises in about half a mile.

North of the Neath Disturbance.

By A. STRAHAN.

Though, as already remarked, none of the north-north-west faults can be traced across the Neath Disturbance, yet out of the large number which occur on either side of that disturbance, it inevitably happens that some fall into one line. Thus a fault which runs along the west side of Cader Fawr ranges for the Werfa Fault, and like it is a downthrow west. But against this must be placed the fact that not one of the group of faults around Ystradfellte crosses the disturbance from the north, and that neither of the Hirwaun Faults crosses it from the south. The Glyn Corwg Fault is commonly supposed to have been recognised at the Pwll-faron (Aberpergwm) Colliery and again at Tir-bach, but the correctness of this view is open to doubt (pp. 63, 64). The faults north of the Neath Disturbance may therefore be fitly described independently of those south of it. The same remark applies to the Cribarth Disturbance.

North of the Neath Disturbance.—continued.

By T. C. CANTRILL.

The Tredegar Fault, so known in the region farther east, enters the area under description near Bryniau Gleision.* It has a downthrow to the north-east, and makes a considerable shift in the Main Limestone escarpment. In two small brooks flowing north into the Callan it throws Lower Limestone Shales and Main Limestone against the Grey Grits, the Lower Limestone being cut out. Beyond the Callan its course is obscure, but the Main Limestone seems to be thrown against the Lower Limestone, and the Brownstone features overlooking Glyn Collwng appear to be broken. This fault has to some extent aided in the preservation of the Bryniau Gleision outlier.

A small easterly downthrow west of the village of Nant-ddu brings the Grey Grits seen above Pentwyn-uchaf down to the same level as the Brownstones of Cefn Nant-y-gougarn.

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* The Country around Abergavenny (*Geol. Survey Memoir*), pp. 42, 84, (1900).

A westerly downthrow runs a short distance west of the Hepste-fechan, and throws down the Main Limestone of Waen Dywarch against the shales. At Glog-lâs the grey oolite (No. 3 of Section on p. 20) is within about 450 yards of the shales exposed in the Hepste-fechan; the beds are in the same line of strike and there is not sufficient room to accommodate the lower beds of the Main Limestone. The ground is greatly obscured by drift and peat, but farther north-west the base of the Main Limestone, which can be clearly traced north-east of Pen-fathor-uchaf, abuts against a feature which appears to mark the base of the shales.

A short distance west of this fault two small fractures appear slightly to dislocate the base of the light oolite (No. 3); one, a downthrow east, lies 300 yards west of Glog-lâs; the other, with downthrow west, runs along the eastern side of Twyn Croes Gwallter. They may be the two faults which cross Cefn Cadlan, but their existence is so uncertain that they have not been shown on the map.

North of the Neath Disturbance—continued.

By A. STRAHAN.

A fault with a downthrow west can be detected without difficulty in the Millstone Grit at Gwaen Hepste. Though less clear in the limestone, its course can be followed to Plâs-y-gors, where it was found by Mr. Cantrill to throw the base of the Main Limestone forward on the west about three quarters of a mile. This fault ranges directly for one of the Penderyn faults, which, however is a downthrow east; moreover, no sign of it could be detected south of the Hepste, and it almost certainly dies out a mile or more north of Penderyn.

We now reach a well-marked group of seven faults which cross the Hepste, Mellte and Neath rivers at an oblique angle, and are well exhibited in the remarkable ravines of those rivers. Two are downthrows east, but the remaining five and more important faults are downthrows west. Not one of the group crosses the Neath Disturbance and only one reaches it; nor is there any corresponding group of faults on the south side of the disturbance.

The easternmost fault of the group throws in one of the small outliers of Millstone Grit south-west of Ystradfellte, and passes northwards along a depression in the limestone-ground to the base of that formation. The next is a downthrow west, which crosses the Mellte below Porth-yr-ogof. Its position is sufficiently obvious where it throws Millstone Grit against limestone, but it dies away in the latter formation. The third fault of the group was described on p. 43 as having formed the upper Clyn-gwyn Waterfall; it is a downthrow west of twenty feet in the Hepste Valley, and of thirty feet in the Mellte Valley, but dies away both northwards and southwards. The fourth is a downthrow east and can be determined in the Mellte and Hepste ravines but not elsewhere. The fifth is a more important fault with a downthrow west, which can be traced for more than five miles. Though it does not exist south of the Neath Disturbance, there is little doubt that it runs into the disturbed belt on the north side; in the Hepste where it brings up a minute inlier of limestone, the fracture is visible (p. 42), and in the Mellte its position is no less clearly fixed by the fact that it throws shales against grit, thus terminating the series of remarkable cascades which constitute the lower Clyn-gwyn Waterfalls. Still farther north its effects are admirably shown in the relations of the Millstone Grit and limestone at Berth-lwyd. At Coed-y-gareg, Mr. Cantrill finds that the base of the limestone has been thrown forward about 200 yards, and that the Lower Limestone Shales are exposed in the Neath as far as Nant-y-môch at a much lower level than their outcrop east of the valley, while the pebbly plateau-beds in the upper part of the Old Red Sandstone occur in the Neath (p. 12) 350 feet below their outcrop on Fan Nêdd, partly at least through the effects of this fault. The sixth fault of the group is a downthrow east, and crosses the Mellte below its junction with the Hepste, where it brings up the basal conglomerate of the Millstone Grit in the brow of the western side of the ravine. The course of this fault along the channel of the Neath near Berth-lwyd, and its effects in repeating the outcrop of the Main Limestone in Nant-y-môch have already been described on pp. 30 and 32, respectively. The seventh and last fault of the group is a downthrow west, which runs 100 yards west of the sixth fault, and is well shown in the bank of the Neath at Pwll-du (p. 30). Several other small faults in the Neath and Perddyn have been already described.

The other faults of the north-north-western system have been discussed in the account of the stratigraphy. Among them we may refer to the Henrhyd Fault (pp. 35, 45), the so-called Glyn Corwg Fault at Onllwyn (pp. 63, 74), the Pwllau-bach Fault (pp. 46, 71), and the Crynant Fault (p. 77). These are all downthrows to the west. One only, the Chapel Fault of Onllwyn, is a downthrow east.

North of the Neath—continued.

By T. C. CANTRILL.

The Henrhyd Fault throws down the Millstone Grit seen in the Tawe at Callwen Vicarage against limestone on the east. It passes probably near Ffynnon-ddu, and cuts the Cribarth anticline west of Penwyllt. On the downthrow side it appears to shift the anticlinal axis slightly to the north. This is in accordance with the fact that the axial plane of the arch is not vertical, but inclined slightly to the south. Beyond the anticlinal axis the fault cannot be traced.

An easterly downthrow makes its appearance in the Tawe Valley a little north of Blaen-Car. At the mouth of the first brook on the east, to the north of the farm, the beds are broken, and the fracture cuts through a loop of the river some few yards still farther north. It then continues along the west side of the Tawe Valley, throwing down Brownstones on the east against the Senni Beds on the west, and dislocating the junction by about a mile (pp. 12, 13). The fracture is visible in Nant y Llyn at a waterfall, the face of which is the actual fault-face. North of this point it appears to be ranging for a large sheepfold on the Tawe, where the beds seem disturbed.

An easterly downthrow slightly shifts the Millstone Grit between Castell-y-geifr and Careg-gôch, and crosses the Haffes at a level dug many years ago in search of iron-ore. On the west the plateau-beds of the Old Red Sandstone dip west at about 30°, and form a low cliff by the side of the river. Opposite the level this cliff suddenly ends, while a little farther down stream blocks of limestone occur which can have come only from Lower Limestone Shales concealed under the glacial drift. The throw of the fault here must be about 60 or 70 feet, and the presence of earthy impure limonite in the veinstuff led to the trial alluded to. Some two miles farther south, at the foot of the Millstone Grit escarpment west of the Saithmaen, may be seen the northern termination of a tramline, which was begun for the purpose of carrying the ore to the iron-furnaces at Ynyscedwyn but never completed. Some broken strata indicated on the map about a mile north of the level are attributed to this fault, and a gap in the scarp at Bwlch-y-Giedd (Sheet 213), may be due to it. It is noticeable that this and the faults next described deviate considerably from the general north-north-west direction.

There is some evidence that the Giedd in its passage across the outcrop of the limestone follows a faulted trough, for at Sink-y-Giedd (p. 20), the Millstone Grit is thrown forward in a promontory, though the displacement is not great. There seems also to be a small intermediate downthrow east along the course of the river. The ground is, however, greatly obscured by drift and the evidence for the faults is not satisfactory.

A fracture is traceable in a north-north-east direction for some distance along Carnau Gŵys; shattered and sparry hard pinkish-red sandstones are seen at intervals along this line, dipping east-south-east and west-north-west. The rocks are folded or faulted down to the west-north-west, but rise again at an angle of 40° in the Twrch, thus producing a syncline. This small trough, together with the much broader and gentler syncline indicated by the west-south-west dips of Fan Hîr and the southerly dips of Breast Twrch, explain that extension of the Brownstone escarpment northwards which culminates in Fan Foel (Sheet 213).

A westerly downthrow ranges in a north-north-east direction through Banwen Gŵys, and throws the base of the Main Limestone northwards for about two-thirds of a mile, to a point in the Twrch which is fixed by an outcrop of the coral-bed (p. 32). The fault probably runs up the course of the Twrch, and may be the cause of the disturbance visible in the Brownstones at Bwlch Blaen Twrch (Sheet 213).

There appears to be a small fault with easterly downthrow crossing the Twrch south of Breast Twrch. The Old Red Grey Grits are thrown down on the east against lower red beds on the west. The fault may possibly extend as far north as the escarpment above Llyn-y-Fan Fâch (Sheet 213), where a small easterly downthrow dislocates the plateau-beds, as mentioned on p. 14.

THE WEST-SOUTH-WEST DISTURBANCES.

The Neath Disturbance.

By A. STRAHAN.

This belt of folding, faulting, and overthrusting is first manifested in some complications observable in the limestone at the head of Dyffryn Crawnon (Sheet 232 *). Passing thence across the Cwms Tâf Fechan and Tâf Fawr, it catches the waters of the Mellte and Upper Neath near Pont-Nêdd Fychan, and from that point to its termination coincides with, and has obviously determined the position of, the Vale of Neath. As usual with disturbances of this character, its structure and effects vary rapidly in different parts of its course. In both Taff valleys it takes the form of a deep-faulted syncline, in which masses of limestone are thrown down to the north of the main scarp and upwards of 600 feet below their normal position. Near Penderyn, on the other hand, it becomes a bold anticline, along the crest of which runs a normal fault with downthrow north. Three miles further on, folding could no longer afford sufficient relief to the pressure, and the fault becomes a crush-plane. A still further stage is reached in another quarter of a mile; folding is less intense, but the limestone has been thrust bodily southwards over a part of the Millstone Grit. At this point the alluvium of the Neath commences and obscures the details of the structure, but it is possible to see that the bottom of the valley is occupied by sharply folded strata, while a comparison of its two sides show that the net result of the folding is a downthrow to the north of about 600 feet. At Blaen-gwrach, however, there is a sudden change, and the disturbance thence westwards is accompanied by a large downthrow to the south.

Neath Disturbance—continued.

By T. C. CANTRILL.

At Bryniau Gleision one of the outliers of limestone alluded to has been thrown in in advance of the main escarpment. The Grey Grits and the Lower Limestone roll over at the head of Nant-du (Sheet 232) from their normal southerly dip to a northerly dip, thus proving the existence of an anticline. In a swallow-hole south-west of a peat-bog shown on the map the Lower Limestone dips south-east, while the Grey Grits and Brownstones are nearly horizontal or dipping to the north-west in a brook close by, which facts give us a second point on the anticlinal axis.

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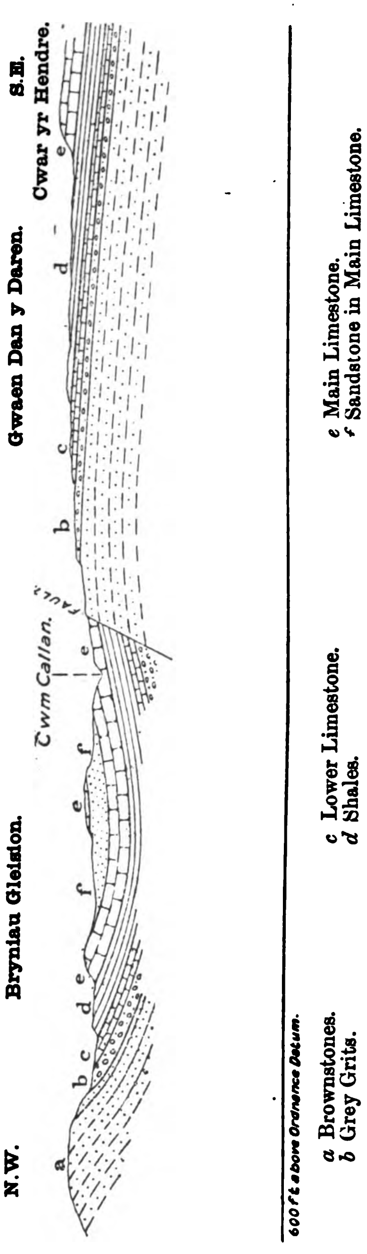
* The Country around Abergavenny (*Mem. Geol. Survey*), p. 28, 1900.

A syncline follows close on this anticline. It is easily recognised in some contrary dips near the Triangulation Station, 1764 (Sheet 232), and again at the south-west end of the outlier both in a tributary of the Callan and along the north bank of that stream. Both syncline and anticline, moreover, are evidenced by the course pursued by the outcrops of the Grey Grit and Lower Limestone. The structure, however, is complicated by a strike-fault with a downthrow north. In a gully west of Glasgwm-uchaf, the fault throws down Grey Grits and Lower Limestone Shales on the north, while south-westwards its course is indicated by a hollow running along the south-east side of the Roman Road. It can be located again, 400 yards west of the peat-bog, in a tributary of the Callan, where it brings Brownstones within a few yards of the Main Limestone, the Grey Grits and Lower Limestone Shales being cut out. There it meets the Tredegar Fault, but possibly continues in the same south-westerly direction along the southern side of Cwm Callan. The accompanying sketch will serve to illustrate further the structure of the outlier.

FIG. 6.—*Section across the Neath Disturbance at Bryniau Gleision.*

By T. C. CANTRILL.

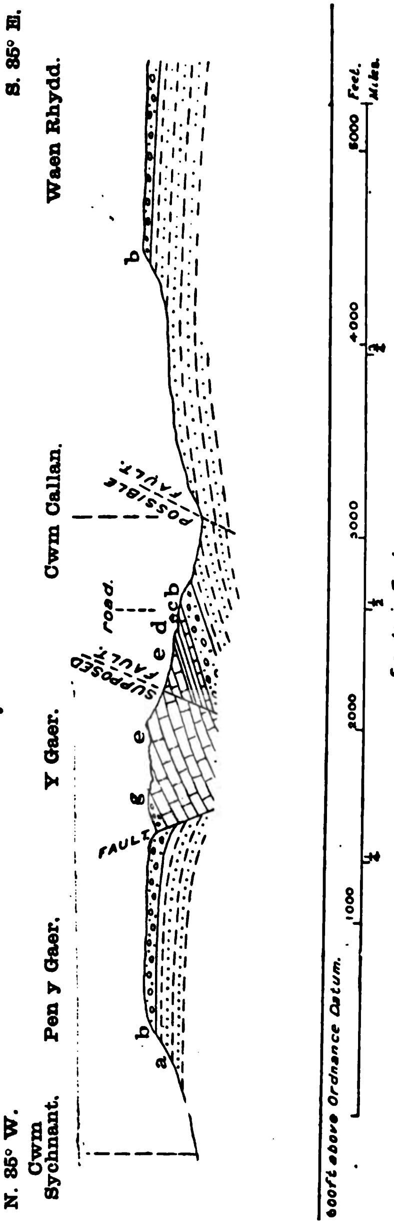


a Brownstones.
b Grey Grits.
c Lower Limestone.
d Shales.
e Main Limestone.
f Sandstone in Main Limestone.

Dolygaer Outlier.—The same general structure is exhibited by the outlier of Dolygaer; there is a broad anticline on the south with a faulted syncline on the north; but whereas in Bryniau Gleision a single fracture follows the middle limb of the fold, in the Dolygaer outlier the syncline is accentuated by trough-faulting, the dominant fracture being a southerly downthrow along the northern edge of the syncline. These points are brought out in the accompanying section.

FIG. 7.—*Section across the Neath Disturbance at Dolygaer.*

By T. C. CANTRILL.



a Brownstones.
b Grey Grits.
c Lower Limestone.
d Shales.
e Main Limestone.
g Millstone Grit.

The soft marly Brownstones exposed in Cwm Callan are greatly disturbed and dip in all directions; but on the northern side of the valley the general direction of dip of the Main Limestone is north-west, while the Grey Grits of Pen-y-Gaer dip a little east of south. We thus recognise the existence of a syncline.

The Coed-hîr fault can be first detected a little west of Blaen Callan Farm, where it throws down successively on the south the Lower Limestone Shales, some of the Main Limestone, and a strip of Millstone Grit against the Grey Grits of Pen-y-Gaer. The Millstone Grit crops out just north of Y Gaer, and the fault is marked by a line of deep and large swallow-holes. A little to the west of these the fault runs down a gully, the northern side of which shows the Grey Grits dipping south-south-east at 60°, while the south side exposes the Main Limestone dipping towards the Old Red at 25°. West of the Reservoir, where the limestone dips east, the fault cuts off all the members of that formation on the strike, throwing them in succession against the Brownstones of Tormwnt.

The existence of the fault passing under Pen-tŵyn Inn is proved by the fact that the Millstone Grit, though it lies not less than 500 feet above the shales (p. 25), closely approaches their outcrop eastwards, the greater part of the Main Limestone obviously being faulted out.

The strike-fault supposed to run along Cwm Callan makes its appearance west of the Tâf-fechan at Ty'n-y-coed, where the evidence is conclusive; limestone is seen west of the house, while 250 yards south-south-west there are Brownstones dipping gently northward. Some of the latter are cut out, as well as the Grey Grits, the Lower Limestone Shales, and some few feet of the Main Limestone.

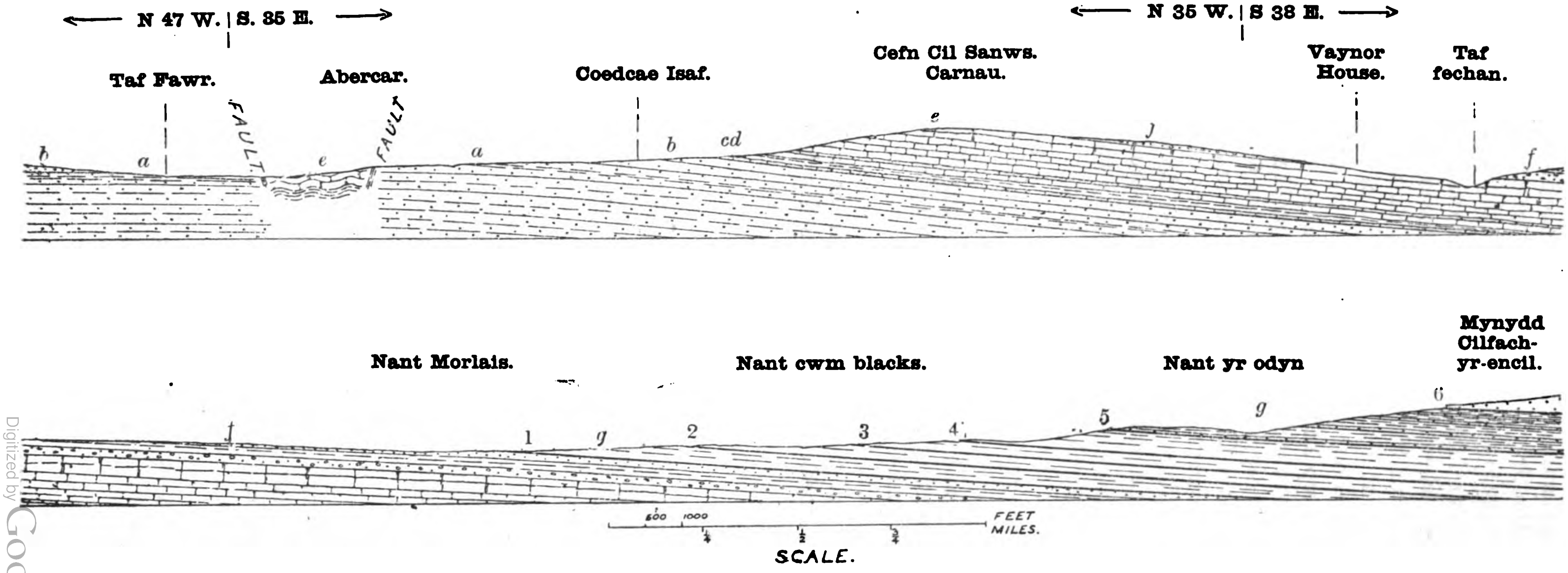
The Neath Disturbance—continued.

By W. GIBSON.

Westwards this fault develops rapidly into a great northerly downthrow, which constitutes the main feature in the structure of the disturbance for about seven miles, inasmuch as it causes the repetition of the limestone across the heart of the Old Red area. On the west side of Cwm Taff Fawr its displacement may be estimated to amount to 300 yards; west of that valley it throws the lower part of the Grey Grits against the upper part of the basal conglomerate of the Millstone Grit, the rocks cut out including about eighty feet of Grey Grits, the whole of the Carboniferous Limestone (about 700 feet) and about eighty feet of Millstone Grit, or nearly 300 yards in all. West of Wern-lâs it cuts out nearly all the limestone, which indicates a displacement of about 200 yards, while at Penderyn the throw is still further diminished, the place of the fault being taken to a great extent by an anticline which runs along Cwm Cadlan. The northern or Coed-hîr fault of the disturbed belt, which is a downthrow south (p. 25), reaches its maximum near Dolygaer and decreases thence westwards. On Cefn Cadlan no fracture can be detected, but a sharp anticline which brings up an inlier of limestone, has taken its place.

FIG. 8.—*Section across the Neath Disturbance at Aber-Car.*

By W. GIBSON.



a Brownstones.
b Grey Grits.
c Lower Limestone.

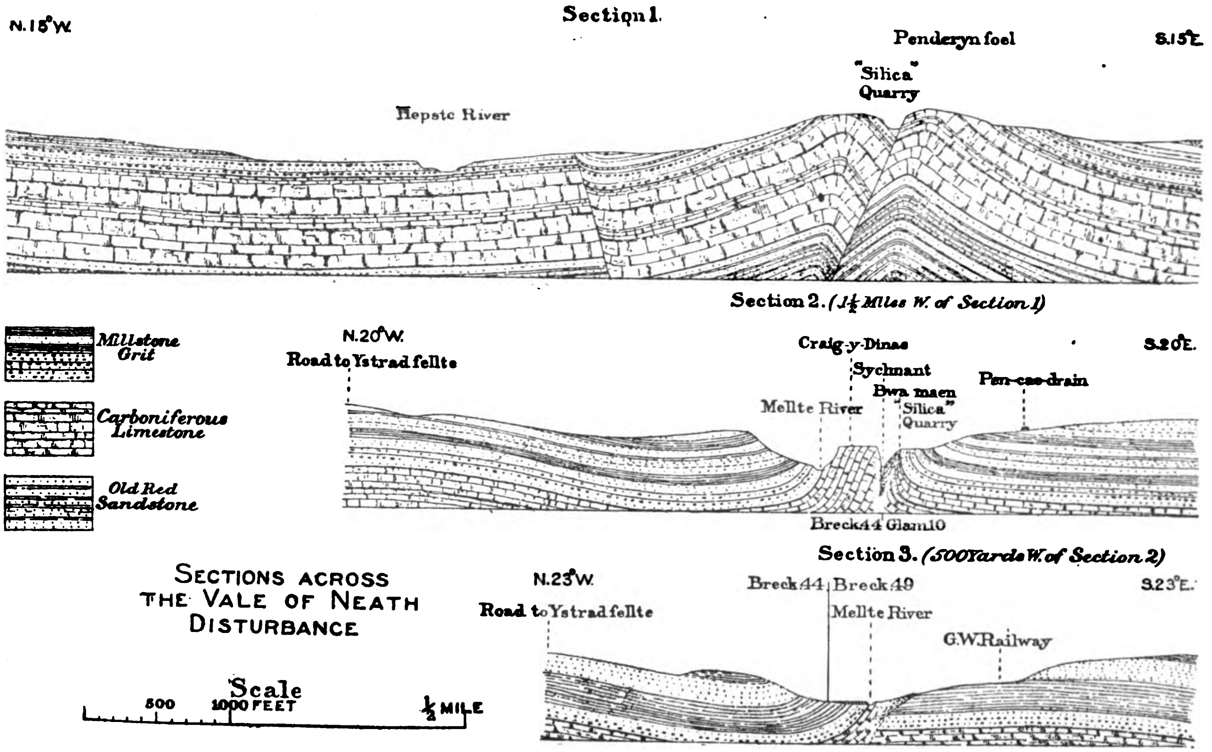
d Shales.
e Main Limestone.
f Millstone Grit.

g Coal Measures with the principal Coal Seams.
1. Garw.
2. Gellideg.
3. Nine-feet.
4. Upper Four-feet.
5. Castell Weaver.
6. Rhondda No. 2.

Sections across the Vale of Neath Disturbance.

By A. Strahan.

Plate II.



[To face page 91

Within the belt of dislocated ground, bounded to the north and south by the faults described above, the strata generally dip east or west, that is at right angles to the normal dip of the region. To this fact may be attributed the variations in the displacements of the faults detailed above. It results presumably from the subsidence having been unequal between the two great faults at different parts of their course from Dolygaer to Penderyn.

At Penderyn the structure undergoes a complete change, and a broad anticline becomes the main feature of the disturbance.

Neath Disturbance—continued.

By A. STRAHAN.

The structure of the disturbance from Penderyn to Craig-y-Dinas is illustrated by the three sections forming Plate II. Section 1 is taken through the great excavation on Penderyn-foel, where crushed Millstone Grit has been dug for the manufacture of fire-bricks. The highly inclined grits and the normal fault are fully exposed in the pit, as depicted in the section, while the faulted syncline shown further north is readily traced in and along the south side of the Hepste. The normal fault alluded to falls into the line of the great northerly downthrow which commences at Dolygaer, and possibly is continuous with it. Whether this be so or not the Penderyn Anticline, which is the dominant factor in the structure, makes its appearance where that fault loses strength, just as an anticline appeared on Cefn Cadlan where the great southerly downthrow died out. (p 89).

Though the small part of the fault exposed on Penderyn-foel shows a normal hade, we soon find reason to suspect that the fracture was due to crush rather than to an expanding movement. It accompanies the anticlinal axis for a mile westwards, keeping on its north side, but passes into the limestone-outcrop at Ffynnon-ddu, and immediately after gains and follows the crest of the anticline. This it follows down the ravine of the Sychnant to the point where Section 2 of Plate II. is drawn. No normal fracture is there distinguishable, but only a belt of broken limestone intersected by an infinite number of veins of calcspar, this crush-rock forming the bed of the river. The syncline to the north is still recognisable, while the main anticline has gained in intensity, and admirably expresses the compression to which the whole structure is due. In the Bwa Maen, or Bowstone, the folding of the limestone has about reached its limit of possible sharpness. In Section 3, 500 yards further west, that limit has been passed, and the limestone of the north side has not only broken away from that of the south, but has been pushed over both it and some of the overlying Millstone Grit. Here relief from the strain was obtained by overthrusting, and sharp folding became no longer necessary. The sections illustrate the development of an overthrust from a broken anticline.

At this point the alluvium begins to overspread the valley-bottom, and gives few opportunities of working out the details of the structure. There is certainly disturbance and a fracture running along the river to an elbow due east of the Angel Inn. Here a fault can be seen, and though it runs along the axis of a syncline it is probably continuous with the anticlinal fault just described. The same fracture crosses the Neath 120 yards below the Angel Inn, while what may be a branch from it traverses the shale-ground north-west of the alluvium and tilts up the strata to a high angle. At Glyn Neath some sandstones exposed in the river dip south-east at 45° to 65°, while the dip at the bridge is north-west at 65°, but these observations are the last obtainable on the position of the syncline. Along the southern side of the valley there runs a parallel anticline, the axis of which crosses the railway near Llwyn-y-gwin and passes under Ynys-onws.

Another local anticline traverses the southern bank of the valley near Ynys-las, for some sandstones in the river and in the side of the railway dip north-west, instead of in the normal south-easterly direction. But for the rest of the distance to Resolven we know nothing of the detailed structure, though the fact is obvious that the disturbance has been accompanied by a large uplift of the strata to the north at that place, as compared with a downthrow to the north at Glyn Neath.

The Cribarth Disturbance.

By A. STRAHAN.

In general character the Cribarth and Neath Disturbances have much in common. Both may be described as narrow belts of contortion, the contortion occasionally passing into fracture and even overthrust. Both belong to a series of disturbances which increase in number and intensity towards the north-west, and each afforded relief to the strain so far as to leave the strata on either side of and between them in an undisturbed condition. In direction also they differ but slightly, for whereas the Neath Disturbance runs W. 24° S., the Cribarth Disturbance keeps a general course about W. 35° to 38° S.

The disturbance was named after Cribarth, a conspicuous anticlinal ridge of limestone flanked by Millstone Grit, but it commences some miles further north in the Old Red region. There, as was the case with the Neath Disturbance, it takes the form of a fracture with a downthrow north. As it develops it is accompanied by the sharp folding which is so admirably dissected in the rocky sides of Cribarth. What appears to be a still further stage is reached in the Coal Measures, where there is a twofold repetition of a great mass of Coal Measures, possibly effected by overthrusting.

The grand exhibition of the effects of the disturbance on Cribarth shows that it consists there of a series of sharp synclines and anticlines. It enables us to see also that though the disturbance as a whole keeps its character for some miles, yet the individual folds composing it rarely run more than half a mile, the principal anticline of Cribarth alone excepted, which continues for more than three miles. The anticlines and synclines, therefore, may be more correctly described as elongated domes and basins respectively, rapidly giving place to one another, and crowded into a belt about half a mile in width.

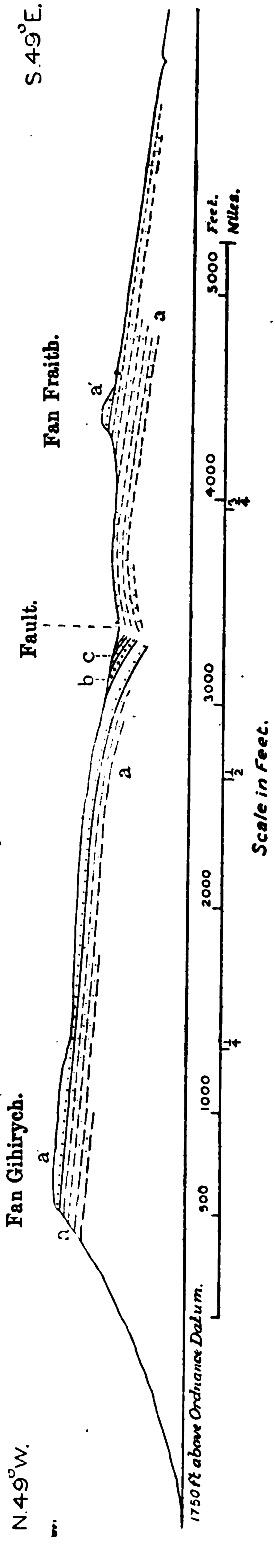
Cribarth Disturbance—continued.

By T. C. CANTRILL.

At the sources of the Neath and Senni rivers, four miles north-west of Ystradfellte, the Old Red beds, which normally dip a little east of south at a low angle, show signs of the oncoming of a disturbance. In the Senni Valley a dip of 35° is shown on the map. A little farther west the beds show a synclinal arrangement; there is, therefore, a suggestion of a gentle anticline on the south followed by a syncline on the north. In the Nêdd Fechan the Brownstones dip steeply to the south and then swing round through south-west to west and north-west, and successively higher beds come in. Near the head of the stream, in the hollow between Fan Gihirych and Fan Fraith, red marls dip south-south-east at 25° as shown on the map; and about ninety yards farther up red sandy marls dipping S. 35° W. are exposed. No more rock in place is exposed, but immediately following the last section are some small blocks of dark limestone at the source of the stream. Then follows much red sandstone detritus, containing a large proportion of pebbly white grit. There can be no doubt that we have here a small outlier of beds belonging to the Carboniferous Limestone series, and that its occurrence here is due in some way to the Cribarth Disturbance. The repetition in Fan Gihirych of the Old Red horizons of Fan Fraith (p. 12) suggests the existence of a northerly downthrow, but whether the southerly dip of the beds in the former is sufficient of itself to bring in the Grey Grits and Limestone beds it is difficult to say; it is quite as likely that there are two parallel faults of opposite downthrow, letting down a trough between them. A little south of the source of the stream, red sandstone dips north at 10°, the normal dips being southerly, so that there is evidence here of a gentle anticline. But in view of the fact that no limestone or grey grit is seen in place, and that the whole of the ground is cumbered with detritus, the exact nature of the faulting must remain obscure. The limestone-blocks may represent a band below or in the shales, or may belong to the Main Limestone; and it is possible that the pebbly white grit is a band interbedded in the limestone-series. The simplest interpretation, as given on the map, is expressed in Fig. 9.

FIG. 9—*Section across the Cribarth Disturbance on Fan Fraith.*

By T. C. CANTRILL.



a Sandstones and Marls of the Brownstones.
a' Plateau-beds of the Brownstones.
b Grey Grits?
c Lower Limestone Shales?

South-west of the last sections the course of the disturbance is located solely by the occurrence of high dips. In Nant Byfre are exposed brick-red sandstones, apparently some of the highest Brownstones, dipping south at 36° and 52° (see map), while sixty yards lower down stream soft green-mottled red sandstone, presumably on a lower horizon, dips in the same direction at 8° to 10°. The fault, with northerly downthrow, probably passes between the two exposures. Dips of 45° and 35° occur in the branches of Nant yr Wydd. In a brook flowing into the Tawyneu east of Dderi the beds are shattered and broken and dip south at 65° and 45°, probably by the effects of a branch fault, as shown on the map. The Neath and Brecon railway is carried over the Byfre by an embankment pierced by a culvert. At the eastern end of the latter, pale red sandstones dip north-west at 30°, and for halfway through the culvert the stream runs over hard red and buff sandstones, dipping steeply in the same north-westerly direction. In the western half of the culvert, however, the stream flows over red sandstones, apparently nearly flat. Presumably the fault crosses the middle of the culvert. At 100 yards lower down stream there is an exposure of greenish-grey fault-rock and red sandstone, dipping north-west at 55°, towards sandstones dipping W. 25° S. at 8°. Presumably the fault-rock marks the fracture. It seems, however to make little throw, for a few hundred yards farther on the base of the Carboniferous series appears to be unbroken, the fault dying out and giving place to the Cribarth fold.

This great line of flexure consists of a well-marked syncline with a parallel anticline on its south side, trending about north-east and south-west. The former is first recognisable in Cwm Crai, where the beds dip towards an axis which can be traced along the eastern side of the valley between the river and the railway. It lies a little east of Bwlch Pen Rhûdd and runs thence down the eastern side of the Tawyneu Valley. It must pass under Callwen Farm and along the steep south-east side of the Tawe Valley, for the limestone at the mouths of the Haffes dips south-south-east. Thence it passes under Blaenau Mill and continues along Nant y Gwared, where it introduces a long trough of Millstone Grit.

The anticlinal axis first appears at Penwyllt. The Lower Limestone Shales there occupy the hollow crest of a ridge, the flanks of which are formed by the Main Limestone, dipping at 25° to 32° south-eastwards, and at 50° to 55° north-westwards on the two sides respectively. The axis thence runs down the side of the Tawe Valley east of Craig y Rhiwarth, where the shales emerge from beneath a complete arch of limestone. It is even probable that the valley under Craig-y-nôs Castle cuts down into the Old Red Sandstone, but the lowest beds actually in sight are Lower Limestone Shales, seen in an old lane at the foot of Craig-y-Rhiwarth.

The strata dip much more steeply into the syncline both from the north and south, than on the south side of the anticline, from which fact two inferences may be drawn, firstly that the principal relief to the pressure was afforded by the doubling down of the rocks into the syncline, and, secondly, that the axial plane of the anticline is not vertical but inclined to the south-east. By analogy with the Neath Disturbance we may suppose that the next stage would have been overthrusting from the south-east.

Cribarth Disturbance—continued.

By A. STRAHAN.

The scarcity of sections which causes so much difficulty in unravelling the structures in the Old Red region cannot be urged against Cribarth ; there anticline and syncline are not only laid open to view, but have even formed corresponding ridges and valleys, the configuration of the ground reflecting to some extent its geological structure. The sections forming Figs. 10 and 11 are drawn across the disturbance 1,800 and 900 yards respectively north-east of Pen-cribarth. The anticline last described forms the principal ridge (A1,) sufficiently wasted, however, along its crest to give a view some little distance down into the limestone (p. 36). Strong as the fold is it comes abruptly to an end at Pen-cribarth, dying after the manner of such structures after a course of about three

FIG. 10.—*Section across the Cribarth Disturbance on Cribarth.*

By T. C. CANTRILL.

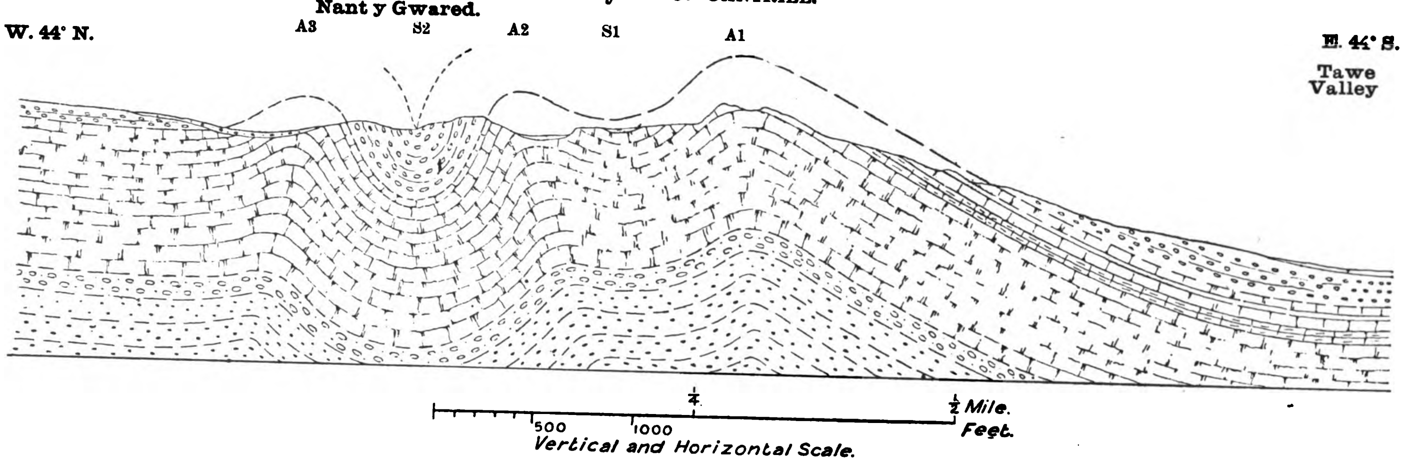
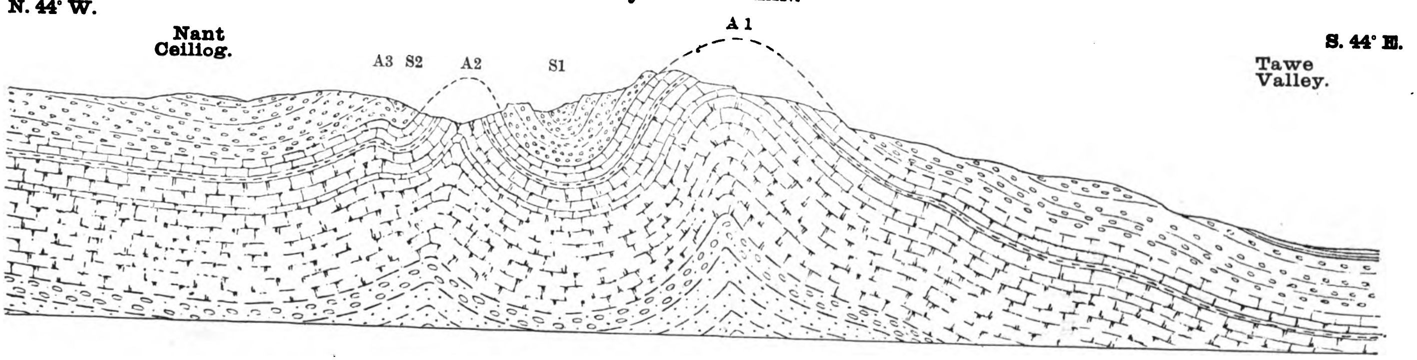


FIG. 11.—*Section across the Cribarth Disturbance 900 yds. S.W. of Fig 10.*

By A. STRAHAN.



Scale same as Fig. 10.

miles. The dips on its north side are extremely steep, and descending more or less precipitous faces of limestone, we enter a trough (S1, Fig. 11) with walls of highly inclined Millstone Grit. Crossing the trough we reach another anticline in which limestone reappears at the surface as an inlier about 500 yards long, but which has formed a hollow instead of a ridge (A2, Fig. 11). This again is followed by a syncline S2, which is on the point of extinction in the line of section of Fig. 11, but which develops eastwards in Fig 10, and passes down Nant y Gwared (p. 95). Finally a third anticline (A3), followed by a syncline which introduces shales near Nant Ceiliog, concludes the series of folds which constitute the Cribarth Disturbance at this part of its course.

The second anticline, namely that which brings up the small inlier of limestone, commences a short distance to the north-east of the inlier, but runs on in the other direction to Garth, where it passes into a fault. The effect of the fault in bringing the top of the limestone-series up to the surface has already been described (p. 36), and the existence of at least two great faults with downthrows north in the Coal Measures near Penrhos was discussed on pp. 72-74. It will be sufficient now to point out that the folding which is so conspicuous in Cribarth is absent at Penrhos, where the dip is almost uniformly south-south-eastwards; while, on the other hand, where folding prevails, strike-faults become scarce. In the Cribarth, as in the Neath Disturbance, the one replaces the other, either having been capable of affording relief to the strain.

CHAPTER VII.

SUPERFICIAL GEOLOGY.

GLACIAL DEPOSITS.

Introduction.

By A. STRAHAN.

In previous parts of the Memoir descriptive of the South Wales Coal Field reference has been made to the important part played by the Brecknock Fans in the glaciation of South Wales. The escarpment of Old Red Sandstone, of which they form part, culminates in Pen-y-Fan at a height of 2,906 feet above the sea, and extends generally in a westward direction to Carmarthenshire, where it ceases to form the predominant feature. In this part of its range it forms the water-parting between the Usk and Towy systems on the north and the numerous streams which traverse the Coal Field on the south, as shown in Fig. 12, p. 100.

The fact that the Fans formed a centre of dispersal of boulders was first ascertained by Professor Edgeworth David* by an investigation of the glacial phenomena of the central part of the Coal Field and of the Vale of Glamorgan. The region now under description was among those examined by him, and one result of the recent mapping of the glacial deposits has been to confirm Professor David's conclusions in all important particulars.

Though there is reason to believe that ice gathered in great force to the north of the escarpment and even crossed it farther west, it seems clear that none crossed the higher part of the range with which we are now concerned. Glacial Drift has been found at all but the highest elevations on the plateau, but nowhere does it contain material assignable to the outcrops on its northern face. The boulders are such as might have been derived from the plateau, and the direction in which they travelled, as proved by the striated surfaces was generally southward, down the long dip-slopes.

The ice-sheet here generated reached the shores of the Bristol Channel, but was split into separate streams by some of the higher ranges of Carboniferous Rocks. One of the most notable examples of such splitting occurs within the area of the map under description. The dip-slopes of the Old Red Sandstone terminate at the minor escarpments formed by the Carboniferous Limestone and Millstone Grit, which rise to a height of 1,500 to 1,800 feet above the sea. These in turn dip southwards, and the general level falls in the same direction, until at the outcrop of the Coal Measures it reaches only about 600 to 700 feet above the sea. So far no serious obstacle lay in the path of the ice. The Millstone Grit hills show glacial striæ in remarkable abundance and preservation wherever the rock is visible. Neither they nor the valleys between them sufficed to deflect the flow from its southward march.

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* *Quart. Journ. Geol. Soc.*, vol. xxxix., p. 39 (1883).

To the south of Hirwaun, however, the ground rises abruptly to the great Pennant scarp, which reaches a height of 1,969 feet at Carn Mosyn. The scarp presents a precipitous front to the north, and extends without a break from the Cynon to the Neath. To the east of it the Cynon, Taff, and other rivers run somewhat east of south; to the west of it the Neath, Dulais, and Tawe flow south-westwards. In this great feature the Brecknock ice-flow found an insuperable obstacle. Unable to surmount the range, it split, a part of it following the Cynon and Taff valleys, and part making for the Neath and Tawe. Between the two, great mounds and ridges of Drift with no definite direction mark the region where the ice hesitated, so to speak, whether to turn to the east or the west of the obstacle. The further history of the two ice-flows and of a third which was generated on the broad Pennant slopes south of the scarp has been given elsewhere.*

The magnitude of the ice-flows referred to is evidenced abundantly in the area under description. That the Taff Valley was inadequate to carry the flow is proved by the fact that the hills on either side of it, such as Cefn yr Ystrad (1,866 feet), Cefn Cil Sanws (1516 feet), and Oen Llŵyn (1,376 feet), are glaciated to their tops. Still more impressive are the proofs of the over-riding of all minor obstacles by the south-westerly flow. Not only did it surmount the Millstone Grit escarpment everywhere, but it crossed obliquely such valleys as those of the Mellte, Upper Neath, and Perddyn without deviating from its course. The Vale of Neath, like that of the Taff, was filled to overflowing, for striæ occur on Hir Fynydd on its western water-parting at a height of 1,300 feet above its bottom. In this overflow is found the explanation of the invasion by the Brecknock ice of certain valleys on the southern slopes of the Carn Mosyn plateau.† The ice-flows, therefore, when at their maximum, did not take the form of valley-glaciers, but constituted lobes of an ice-sheet by which all but the biggest features of the region were ignored. Towards the south, several miles beyond the obstacle by which they were parted, the Taff and the Vale of Neath flows tended to re-unite.‡

The glacial deposits of the region with which we are now concerned may be all described as Brecknock drift with the following exceptions. The Boulder Clay on the Carn Mosyn escarpment, above a level of about 750 feet above the sea, is of local origin, and that in the Glyn Castle Valley, in the Rheola and Crynant Brooks

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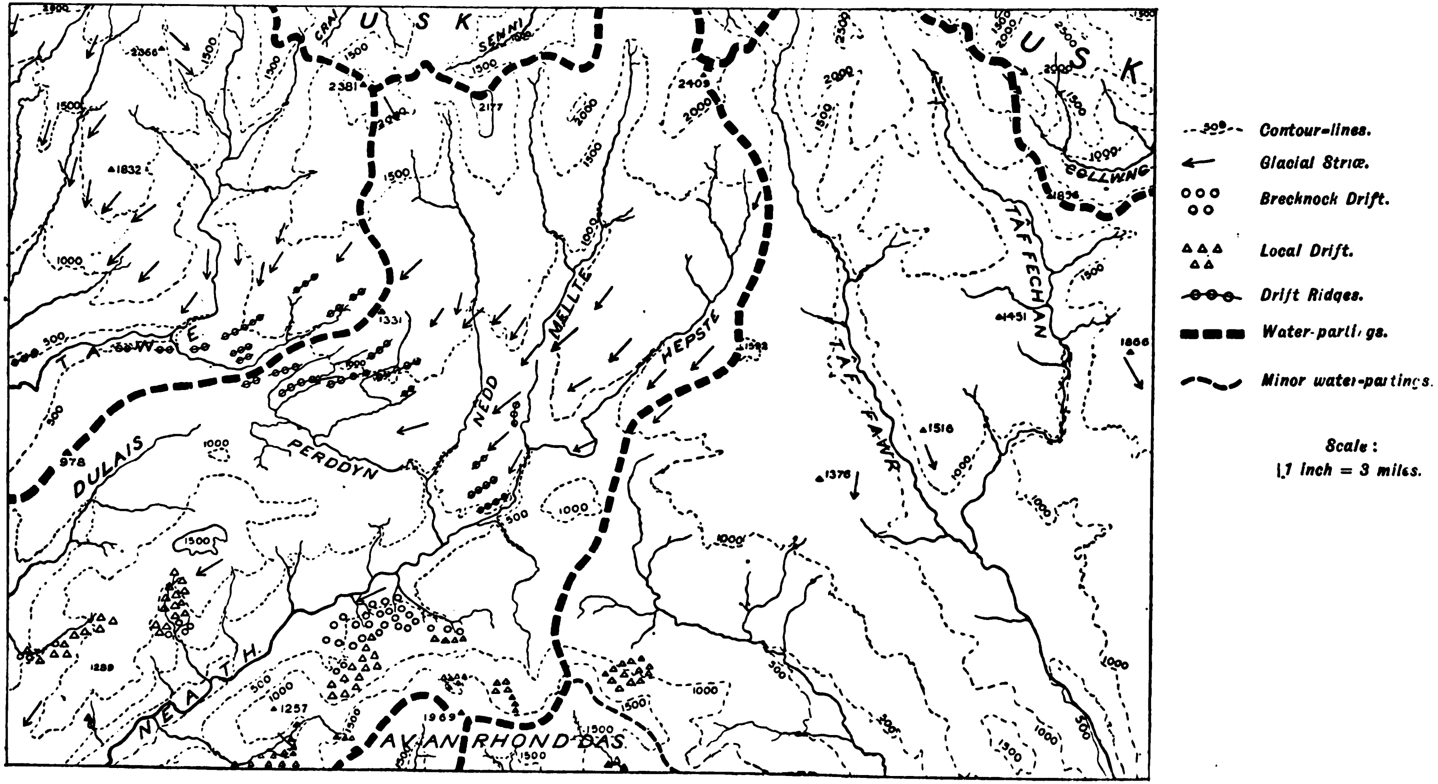
* The Country around Pontypridd and Maesteg (*Memoir Geol. Survey*) Chap. ix.

† The Country around Pontypridd and Maesteg (*Memoir Geol. Survey*), p. 120.

‡ *Ibid.*, p. 114.

FIG. 12.—*Map showing the Watersheds, Distribution of the Drifts, and the Glacial Striæ.*

(A. STRAHAN.)



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and some other deep cwms has been derived from the rocks cropping out in the neighbouring hillsides. In all cases this local drift graduates insensibly into that of more distant origin.

The Brecknock drift, near its source on the Old Red Sandstone moorland, is composed wholly of the detritus of that rock. Being an unstratified deposit, with boulders but little rounded, it is classed as a Boulder Clay, but having been derived from a formation in which arenaceous material predominates it is of a gravelly character. Southwards, within the Carboniferous area, Carboniferous boulders enter largely into its composition, the quartz-conglomerates and grits of the Millstone Grit being especially ubiquitous. In the Coal Field, where shales predominate, the deposit assumes the character of a typical Boulder Clay, and the red gravelly matrix gradually gives place to a stiff blue clay.

True gravels, that is, stratified deposits with well-rounded pebbles, occur but rarely. So far as concerns the region under description they are confined to parts of three of the main valleys, where it may be supposed that effluents found their easiest exit from the ice-sheet. On the other hand, towards the southern part of the Coal Field and towards the southern margin of the glaciated area generally, pebble-gravels predominate.*

Below many of the bolder precipices, ridges or crescentic mounds of angular material have been piled up in true morainic form. A water-logged hollow usually separates the ridge from the precipice, and sometimes contains a lake, as in the case of Llyn-fawr and Llyn-fach under the Pennant scarp; but the characteristic features are better shown in some of the larger cwms in the Old Red Sandstone hills. Similar morainic ridges have been developed near Abergavenny † and in other hilly regions, such as the English Dale District,‡ and parts of Scotland and Ireland. From the fact that the majority of the cwms face north or north-east, it has been argued that snow must have lain in them longer than elsewhere, and that on its sloping surface the talus which now falls to the foot of the cliff may have been carried to a distance, but it seems necessary to assume that in some cases at least there must have been a small glacier possessing a proper motion of its own.§

The Boulder Clay is frequently arranged in mounds or ridges of gentle contour with their longer axes pointing in the direction in which the ice was moving. In a broad tract of Boulder Clay on the north side of the Perddyn these ridges have determined the local drainage. A series of rivulets, after flowing west-south-west between the ridges, is intercepted by the Perddyn and the water carried back eastwards. In the same neighbourhood there occurs a huge mass of grit, which has been transported from some adjacent outcrop.

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* The Country around Cardiff (*Memoir Geol. Survey*), 1902, p. 78.

† The Country around Abergavenny (*Memoir Geol. Survey*), 1900, pp. 90, 91.

‡ The Country around Ingleborough (*Memoir Geol. Survey*), 1890, pp. 90, 91.

§ The origin of such cwms and of the detrital accumulations in them is discussed by Mackintosh in *The Scenery of England and Wales* (1869). pp. 187–204, and by Kinahan in *The Geology of Ireland* (1878), pp. 309–313.

Striated rock-surfaces occur so commonly that it is needless to enumerate the localities, but the following may be mentioned as being of special interest. On the slopes of Torpantau, at a height of 2,250 feet above the sea, striæ range south-east, towards Nant Bwrefwr, by which the ice has been slightly influenced. Further south the normal direction of ice-flow is recorded by many striæ on the Millstone Grit as S.E., that is exactly parallel to the neighbouring part of the Taff Valley. Viewed broadly, the ice, here as elsewhere, followed the general direction of the main valleys, but kept its course, so far as its upper layers were concerned, across their deviations. Minor valleys were ignored.

East of the Taff-fawr the direction becomes slightly west of south, as shown north of Nant-ddu, or about south as on Oen Llwyn, showing that the water-parting between the Taff and the Cynon was crossed obliquely. A mile or two further west the ice came within the influence of the Neath and Tawe Valleys, and the south-westerly flow became established. That direction prevailed over nearly all the remainder of the region under description, and striæ varying but little from it abound on the Carboniferous rocks, the limestone and Coal Measure shales excepted.

On the Old Red Sandstone, however, in the neighbourhood of the main water-parting, we find no such uniformity in the direction of striation. On Fan Fraith, for example, the striæ run S. 35° E., and in a brook close by, nearly east, and again a mile to the S.E. of Fan Fraith they run from 18° to 26° east of south. These localities lie within the region of south-westerly flow, but the direction of striation has been determined by the local configuration of the ground. Similarly on the broad slope at the foot of the Fan Hîr scarp the striæ follow a direction which is obviously due to the form of the ground, and does not agree with the glaciation of the region as a whole. It would seem, therefore, that in the area where the ice was generated its movements were more subject to influence from the local features than in regions further removed, where it had gained sufficient volume, and was actuated by sufficient *vis à tergo*, to surmount minor obstacles.

The Taff Valley (*Upper Part*).

By T. C. CANTRILL.

The glacial deposits on the southern slopes of the Fan range form narrow strips along the valleys where these cut down deeply into the Old Red Brownstones, but farther south, where the valleys become shallower, the drift often creeps over the intervening moorlands and frequently extends east and west from valley to valley.

East of the Tâf* Fechan, on the high plateau of Gwaen Cerig

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* The Welsh spelling of this name holds its ground in the upper reaches of the valley, but has been replaced by the anglicised form *Taff* in the lower reaches.

Llwydion and Torpantau, there are two well-marked glaciated pavements shown on the map; the north-eastern one occurs by the side of Nant Gyrfanell about 170 yards up stream from the edge of the plateau and at an altitude of 2,250 feet. The striæ are shown on some red gritty flags exposed by the side of the stream, and point in a direction S. 62° E., indicating a flow down the scarp into the Gyrfanell Valley. The second and much better example occurs 470 yards to the south-west of the other, and a few yards north of the boundary-stone named Garn Fawr on the six-inch map, Brecon 40 N.W. From this point a bare dip-slope of gritty sandstone extends in a north-westerly direction for about 300 yards with a breadth of twenty or thirty yards, and on it are numerous small striated patches. The average height of these is about 2,250 feet above the sea, and the striæ are directed towards S. 50° E., indicating a flow towards the Bwrefwr Valley. The ice would seem to have moved down the gentle dip-slope from the direction of Craig Cwm Oergwm (2,393 feet), and there is little doubt that the Beacons themselves (2,907 feet), which lie on the same inclined plane as the striated rock and some two and a half miles to the north-west, were covered by ice at the time of the striation.

The drift in the upper part of the Tâf Fechan Valley consists of the usual sandy debris more or less moundy, and full of subangular stones, few of which are striated. It was laid open in several cuttings on the contractor's railway in connection with the Merthyr Waterworks in the year 1897. Three well-marked mounds are to be seen one-third of a mile south of Torpantau Station. South of the Coed-hîr Fault the Old Red type of drift immediately gives place, on the western side of the reservoir at Dolygaer, to a drift formed almost exclusively of limestone, as shown in a section at the western end of the dam. On the eastern side of the reservoir the drift is gravelly and consists almost wholly of Old Red Sandstone material. There is little drift in Cwm Callan except boulders of limestone from the Bryniau Gleision outlier. On Gwaen Tâf, a group of irregular mounds lies opposite a slight recess in the cliffs east of Cefn Cûl; and another set of irregular ridges occurs in a similar situation east of Bwlch Duwynt; they seem to be comparable to the corrie-moraines or snow-screes already described.

The moorlands west of Cwm Tâf Fechan are almost devoid of drift, and only faint and doubtful traces of striation occur on the plateau west of Graig Fan-ddu at an altitude of about 2,350 feet. The supposed striæ point about S. 50° E., down the Tâf Fechan Valley.

The Tâf Fawr Valley is a 'through' valley and communicates directly by a pass with the head of Glyn Tarell as further described on p. 117. Faintly marked mounds strewn with blocks occupy the western side of the pass itself, and from the fact that drift runs continuously from the one valley to the other, it follows that the pass was cut before, at any rate, the close of the glaciation, and has not been deepened since. On the contrary, post-Glacial operations have evidently tended to fill it up. At the disappearance of the ice from the pass the hummocky surface of the ground was to some extent overspread with a fan of coarse gravel from the stream, known as the Tâf, which enters the pass on the eastern side, some half mile south-east of the divide. North-west of this fan the ground up to the divide has gradually silted up with finer rain-wash and now forms a rushy peat-flat, through which one of the drift-mounds still projects. None of the drift-material in the pass can be attributed to outcrops in Glyn Tarell, and it appears certain that the present water-parting is practically identical in position with the former ice-parting.

The till along the eastern side of the Tâf above the Storey Arms runs up the south side of Nant-yr-Offeiriad nearly as far as its source on the west side of the Beacons, and contains striated stones at an altitude of about 2,100 feet.

A number of remarkably well-defined mounds occur at the mouth of Nant Penig on the west side of the new reservoir of the Cardiff Water Works, a mile south of the Storey Arms. During the construction in 1897 the bottom of the valley was found to be covered with subrounded stones and a few large blocks ranging up to six feet in length—some of which were striated—in a sandy and marly matrix all of Old Red origin. For a considerable distance above and below the mouth of Nant Penig the bed of the Tâf exhibited no solid rock, and it was stated by Mr. Fred. Orton, the engineer, that on the upper side of the dam at its western end, the smooth surface of the solid rock lay at as much as about twenty feet below the level of the stream.

An excellent example of a corrie-moraine occurs in the cwm at the eastern foot of Fan Fawr.

At one-third of a mile south of Nant-yr-eira the side of the contractor's railway shows gravelly till with striated stones resting against what looks like a water-worn surface of sandstone; and a similar phenomenon was still better displayed on the side of the same railway at a point midway between Berth-lŵyd and Pen-tŵyn-uchaf; rounded blocks of sandstone and shale—not striated—resting against a distinctly water-worn and not glaciated surface of sandstone at a height of at least seventy feet above the river.

In Nant-gôch east of the reservoir below Cwm Crew, the till is banked up against the valley side; and the smoothness of the rock suggests glaciation.

The head of Cwm Crew presents a perfect example of the corrie-moraine of the usual sandy and marly debris, full of angular, subangular, and occasionally striated stones. Much of this moraine lies above the 2,250 feet contour. At the head of Nant Ddu a strip of gravelly till containing striated stones borders the western side of the stream and ends off just below the edge of the superjacent plateau at an elevation of over 2,000 feet.

Below the mouth of Nant Ddu the drift on the western side of the Tâf Valley becomes more gravelly.

West of the Tâf Fawr Valley a small striated patch of bare rock on Pant-y-Waen indicates an ice-flow in a direction S. 25° W. Red clayey till containing many well-striated stones is exposed in the banks of Nant-y-Cwrier just north of Carn Caniedydd, and it is likely that much of the moorland between Nant-y-Cwrier and the Hepste is overspread with similar drift.

The Tâf Valley (lower part) and the Cynon Valley.

By W. GIBSON.

The glacial deposits belong to two types of distinct origin. The greater mass of the drift occupying the valleys in the Old Red Sandstone and entering the Tâf and Cynon Valleys has been carried to its present lodging-place by the Brecknock ice-sheet. It is made up of well-washed sand and gravels in the Tâf Fawr and Tâf Fechan Valleys north of the limestone-escarpment, and of a stiff clay filled with erratics within the Coal Field. The second type of drift consists of piles of angular blocks set in a clayey matrix, and is met with on the high Pennant plateau south of Hirwaun and in the cwms at the foot of the scarp in which the plateau terminates. This material is entirely of local origin.

The direction of flow of the Brecknock ice has been influenced by that of the main valleys. Thus the glacial striæ on Gwaen Cefn-y-gareg and Cefn Cadlan run south-west in the direction of the Neath and Tawe system; while those on Cefn Cil Sanws, north of Cefn, point a little east of south and are parallel with the Tâf Valley. Similarly those on Cefn yr Ystrad are directed towards the Tâf Bargoed Valley, and cross obliquely the Tâf Fechan, where it turns abruptly to the west and enters the narrow gorge between Pontsarn and Cefn. The Tâf Bargoed Valley, on the other hand, is wide and open towards the north-north-west, and is the dominant valley east of Dowlais.

The direction of the ice-movement is clearly demonstrated by the striated and grooved surfaces of bare rock. The striæ are admirably preserved on the quartz-conglomerate of the Millstone Grit, owing to its being a highly siliceous rock yielding but little to weathering; but they seem to have disappeared from the exposed surfaces of the more easily weathered Carboniferous Limestone, and are not frequent on the crumbling Pennant Grit. In the bed of a stream on Cefn yr Ystrad the quartz-conglomerate of the Millstone Grit is distinctly striated in a direction S. 25° E. The striæ occur close to the Trigonometrical Station (1,866 feet Ordnance Datum). On Cefn Cil Sanws the direction is S. 12° E.; on Oen Llwyn the trend is nearly due north and south; on Cefn Cadlan S. 38° W.; and on Gwaen-cefn-y-gareg S. 42° W. At the last-mentioned locality large surfaces of quartz-conglomerate are exposed with grooving, scratching, and moulding as fresh as those of a recently glaciated area.

In the Tâf Fechan between Dolygaer and Pontsticill the drift is confined to the bottom of the valley, and consists of a coarse gravel piled up in mounds and ridges. South of Pontsticill a coarse till lines the side of the valley. The fragments include blocks of Carboniferous Limestone, frequently striated, Old Red Sandstone and yellow grits, the whole being firmly cemented together by infiltrated carbonate of lime. A similarly compacted deposit occurs in the deep gorge of Nant Ffrwd to the west of Cefn, and it is noticeable that both gorges run transversely to the direction of main ice-flow.

The ice which thus transversely crossed the Tâf Fechan deposited considerable detritus round Dowlais, and especially to the north of Dowlais Top Station. The drift, which accumulated here to a depth of over thirty feet, is made up chiefly of striated blocks of Old Red Sandstone, Carboniferous Limestone, and quartz-conglomerate. Some isolated patches on Merthyr Common, at a height exceeding 1,200 feet, were probably carried thither by the ice travelling in the direction of the Tâf Bargoed.

In Cwm Tâf Fawr the drift lying in the bottom of the valley between Nant-ddu and Cefn is of a gravelly nature, while that mounting the valley-sides, to a height of over 1,250 feet above the sea, around Ynys-y-felin resembles an open-textured till and retains this character between Cefn and Troed-y-rhiw, but the proportion of foreign material grows less to the south of Merthyr. The drift seldom rises above the 1,000-feet contour.

In the Cynon Valley the glacial material shows the same character. Around Hirwaun it is thick, and to the north of the town it is piled up into mounds between which peat-bogs and swamps ramify in an irregular manner, these mounds indicating the spot where the Brecknock ice parted in its course for the Neath and Cynon Valleys.

The Carboniferous Limestone of Mynydd y Garn, to the west of the Hepste, is thickly strewn with large blocks of Old Red Sandstone several feet in length. A few of the larger blocks remain perched on the bare rock in the position in which they were left by the ice. Small isolated patches of glacial deposits containing fragments of Old Red Sandstone are met with on Cader Fawr close to the 1,500-feet contour, and form one of the many proofs that these hills were over-ridden.

The Hepste, Mellte, and Neath or Nedd (upper part).*

By T. C. CANTRILL.

The Hepste shows several good sections of gravelly till twelve to fourteen feet thick and containing sub-rounded blocks of red sandstone up to six feet in length. To the west of it much of the Carboniferous Limestone outcrop is buried under Old Red Sandstone drift containing apparently little or no limestone. Some blocks of pebbly white grit are occasionally met with, derived from either grits not seen in place but presumably interbedded in the limestone, or from patches of Millstone Grit debris.

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* As in the case of the Taff, the Welsh name is used for the upper reaches, and the anglicised form for the lower reaches of this river.

In the Dringarth Valley the drift forms a well-marked terrace on each side of the river above Blaen Dringarth.

In the Llia Valley, till forty feet thick overlying Old Red sandstone and shale is exposed in a bend of the river opposite Blaen Llia; and on the western side of the valley it forms a well-marked ridge terminating at three-quarters of a mile north of the mouth of Nant-y-Groes. Near the upper limit of this drift, on the tongue which rises above the 1,500 feet contour, lies a block, four feet six inches long, of grey cornstone, which has certainly travelled down the valley from some point as far north at least as the Maen Llia.

West of the Llia the drift overspreads much of the Carboniferous Limestone outcrop. A well-rounded boulder of green calcareous sandstone, with a large block of cornstone close by, lies 600 yards south-west of Plâs-y-gors; both must have travelled down the Llia Valley from outcrops near the Maen Llia.

In the Nêdd (Neath) Valley, above Nant-y-Môch, excellent sections show the drift to be forty to fifty feet thick, with some faint signs of bedding. It consists of Old Red material and contains striated stones in unusual abundance. The alluvium above Coed-y-gareg terminates northwards against the semicircular face of a well-marked drift-mound, the form of which is apparently due to original deposition and not to circumdenudation. At the head of the main valley moundy drift appears to cross the divide into the Senni Valley. In the south bank of the Nêdd-fechan, half a mile west of the Nêdd, a small highly inclined surface of sandstone at the water's edge is striated by ice which moved along and presumably down the stream. Still higher up the stream, in the hollow between Fans Gihirych and Fraith, red boulder-clay, chiefly of marl-débris and full of striated stones, borders the stream at a height of over 2,000 feet above ordnance datum. A small exposure of red grit on the eastern side of the summit of Fan Fraith is bevelled and striated in a direction of S.35°E. It has an altitude of about 2,110 feet. The striæ are due to ice which seemingly filled and overflowed from the hollow between the two Fans.

The Hepste, Mellte, and Neath (upper part)—continued.

By A. STRAHAN.

At Ystradfellte, and on much of the limestone-outcrop generally, the drift contains little beyond Old Red detritus. Striæ are distinguishable on the limestone at a bend in the river 600 yards north of Porth-yr-ogof, and abound on the Millstone Grit. They run S.50° to 53°W. on the east side of the river, but on the other side gradually turn to a direction S.20°W. The freshness of their preservation is remarkable, even the minute striation of the quartz-pebbles being discernible, as well as the larger groovings of the grit-surfaces. The direction of flow, moreover, can generally be ascertained by the fact that many of the pebbles, projecting slightly, have protected the rock on their leeward sides from abrasion and have given rise to a little ridge.

Along the edges of some of the ravines the grits have cracked in long slices and sagged over. It is interesting to see that the striæ keep their direction on these slipped masses, showing that the slipping took place in pre-glacial times. In this and the fact that glacial deposits occur on the bottoms and sides of the ravines, wherever there is room for them, we find proof that the valleys are of pre-glacial age, and are the more impressed with the magnitude of an ice-flow which could so completely ignore them.

Proceeding southwards we pass gradually on to a bluish clayey drift, derived from the shales of the Millstone Grit, but packed with more or less angular blocks of grit and Old Red Sandstone. Scratched stones abound, and striated rock-in-place occurs north-east of Carn-y-crochan (S.45°W.), near the Hepste ravine a mile further east (S.55°W.), and half a mile north-west of Carn-y-crochan (S.53°W.) The drift-ridges run also in this direction near Hendre-fydd, and the fact that the glaciation, while following the general direction of the Vale of Neath, crossed its upper tributaries obliquely, is strongly emphasised.

Hirwaun to Blaen-gwrach.

By A. STRAHAN.

The Boulder Clay, which overspreads the lowest Coal Measures west of Hirwaun, contains sufficient Old Red Sandstone to show that it belongs to the Brecknock distribution, but the majority of the boulders in it near Tyle-morgrug are attributable to the Millstone Grit, while further south in the old patch-works the clay is dark and composed chiefly of Coal Measure material. The low drumlins into which the drift has been piled enclose peat-bogs and run east and west, inclining a little to the south of east as they approach Hirwaun. Scratched stones abound. The mass extending from Whalby to Blaen-gwrach has been deeply trenched by the turbulent stream of Cwm Gwer-elech and its tributaries, assisted by the "scouring" of the mine-ground. Near Pen-rhiw it contains plenty of pebbly grit and Old Red Sandstone, but at Glyn Eithinog and thence southwards it is devoid of those rocks, while at the same time it becomes a dark clay made up wholly of local Coal Measure shale. Between the two places runs an indefinite line along which the Brecknock ice amalgamated with the local ice generated on the Pennant scarp. The former here ascended the slope to a height varying from 650 to 750 feet above the sea.

Westward from Cwm Gwer-elech we pass several deep rain-gutters showing upwards of twenty feet of a strong till with many blocks of pebbly grit or Old Red Sandstone, while the fields also are strewn with large blocks of the former. Here again these boulders of northern origin become scarcer southwards up the slope and may be said to disappear at about 650 feet above the sea.

Striæ pointing straight down the Neath Valley have been noted on the brow of a cliff overhanging the railway 300 yards east of the culvert of Cwm Rhyd-y-gau.

The fact that the Brecknock ice reached no higher than 750 feet on this hill, although it reached 1,450 feet on Hir Fynydd proves that local ice occupied the slope in considerable bulk.

Hirwaun to Blaen-gwrach (*continued*).

By W. GIBSON.

The hollow in the hill near Blaen-gwrach Farm along the Glyn Corwg Fault is drained by nearly a dozen deep gutters. In their upper part, where they cut into Boulder Clay to upwards of twenty feet without reaching its bottom, they show local boulders only, but near the 700-feet contour Old Red Sandstone and Millstone Grit blocks appear in rapidly increasing abundance. Although the Brecknock ice may have reached higher levels than indicated by the existing drift, the absence of any Brecknock boulders, even in the depressions on the high Pennant plateau of Carn Mosyn shows that it did not overflow the escarpment. On the other hand, the thickness, coarseness, angularity and entirely local nature of the drift filling Cwm Clydach plainly prove that the plateau nourished a small local glacier. The detritus of this ice is met with at the head of the Rhondda and in a hollow to the west of Twyn Corwg-fechan and at a few spots in the adjoining map (Sheet 248). In Cwm Clydach between Hendre-Owen-fach and the Glyn Castle Colliery, where the deposit is of unusual thickness, it is entirely made up of large blocks of Pennant grit with a small amount of clayey matrix. Many of the rocks are clearly striated, and a large mass in the stream south of Hendre-Owen-fach, measuring fourteen feet long and nine feet wide, is distinctly grooved. Mounds, composed of local Coal Measure detritus, rest in the three deepest hollows or cwms at the foot of the Pennant scarp, and form good examples of the morainic material which has been attributed to "nestling glaciers." Of the three cwms referred to, one contains a shallow lake known as Llyn-fach, the second a larger and deeper lake known as Llyn-fawr, while the third, at the foot of Craig-y-bwlch, contains only a swampy hollow. All face about north-east, and receive but little direct sunshine; Llyn-fawr reputedly none. The Craig-y-bwlch mounds which run down to a much lower elevation than the others, stop above the 800-feet contour, and therefore above the limit of the Brecknock ice.

The striæ noticed by Professor Edgeworth David* as occurring one and a half miles east of Carn Mosyn could not be found, the only striated rock-surface met with being one in the bed of the Clydach near Hendre-Owen-fach. In both instances, the striation is attributable to the local ice-sheet and not to the Brecknock flow.

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* *Quart. Journ. Geol. Soc.* vol. xxxix. p. 51 (1883).

West of the Nêdd and the upper reaches of the Tawe.

By T. C. CANTRILL.

West of the Nêdd again the Old Red drift spreads over the outcrop of the Carboniferous Limestone; as the ice approached the higher bands of the limestone it picked up a large admixture of white grit and conglomerate debris, the greater part if not the whole of which was derived from disintegrated Millstone Grit which overspread much of the limestone-outcrop in pre-Glacial times (see p. 48). This abundance of white grit material is particularly noticeable in the hollow north-west of Sand Hill.

In this neighbourhood two cases of stream-diversion have been met with. East of Carn yr Onen a stream rises on the dip-slopes of Old Red Sandstone, flows south-eastwards along the outcrop of the Lower Limestone Shales, and seems originally to have continued eastwards into Nant-y-Môch. Now, however, it sinks into a swallow-hole at the base of the Main Limestone at the western end of the peat-bog shown on the map, and presumably emerges at several strong springs about a mile to the south-east. The diversion into underground channels seems to have been brought about by the blocking-up of part of the original course with drift.

A better instance is that of the river Byfre. This stream, which rises near the summit of Fan Gihirych, flows down the dip-slope of Old Red Sandstone and no doubt originally continued along the base of the Carboniferous Limestone into the Tawe near Capel Callwen. But during the glaciation its course became choked with till at the foot of the limestone-escarpment, and the river seems to have found it easier to make its way down a swallow-hole (Pwll Byfre) and thence by underground channels than to cut through the obstruction. Consequently, the Upper Byfre now issues from a cavern (Ffynnon Ddu) by the side of the Tawe a mile and a quarter below the mouth of the Lower Byfre. That stream arises chiefly from the peat-bog, possibly once a pool, which now covers the obstructing detritus. Sawdust or bran thrown into the stream at Pwll Byfre is said to have re-appeared at Ffynnon Ddu.

Between the Nêdd and the Tawe Valleys the extensive dip-slopes of the Millstone Grit conglomerate everywhere afford evidence of severe glaciation. Glacial material is rare, and such boulders as occur have been derived chiefly from the grit itself. Many of the blocks have been left perched on the edges of crags in a position such as they could not have attained by gravity alone, notably at a point half a mile north-west of the peat-flat west of Sand Hill. The Saith-maen (Seven Stones) south-east of Penwyllt is a line of perched blocks of grit standing on a bare dip-slope of glaciated grit the striæ on which point S. 32° W., the blocks themselves being ranged along a line bearing about S. 20° W. They are many more than seven in number, but probably many of the smaller blocks are fragments of larger ones broken down by the weather. There is no reason to doubt that the arrangement is natural, though it would be difficult to disprove human interference.

The outcrop of the grit shows many bare glaciated patches too numerous to be all indicated on the map. The ice moved in a general south-west direction, but near the eastern side of the Tawe Valley began to feel the guiding influence of that channel, and the striæ gradually become more southerly in their trend till at Penwyllt they average S. 7° W., and point directly down the valley.

Most of the grit-crags are bevelled on their edges and many are striated on their faces, as for example by the side of the Neath and Brecon Railway at 150 yards south of the Penwyllt Silica Brick Works. A narrow dip-slope of grit bounded laterally by joints becomes by the bevelling of its edges a *roche moutonnée*, such as may be seen on the tongue of grit running north-east from Careg Cadno, and again 200 yards east-south-east of the Penwyllt brick-works.

The drift of the Tawe and Tawyneu valleys north of the Limestone base consists of the usual gravelly till. In Nant-yr-Wydd, where it shows signs of horizontal bedding, it consists of sandstone and marl-debris thirty to forty feet thick, with subrounded and striated blocks up to five feet in length. In the most southerly branch of the stream at 250 yards above the railway the drift is banked up against a cliff of pebbly grit overlying sandstone, the edges of which are bevelled and appear to be striated. Good sections of till are exposed in the brook next south of Nant-y-Llyn, and in the Tawe Fechan. This brook at the point marked on the map by a dip-arrow of 11° (west of Blaen-Car) shows thirty feet of till resting on sandstone. A little farther south is an alluvial flat, possibly once a small pond, bounded along the north-east side by a block-strewn ridge which may be a snow-scree or moraine. The stream seems once to have overflowed by a notch on the eastern side of the flat and to have joined the Tawe at Llwyn-yr-yn; it now escapes by a gully cut through drift at the south end of the flat, and thus resumes its original course.

At the foot of Fan Hîr a fine example of a snow-scree or moraine has been dignified by the name of Fan Fechan (six-inch map, Carm. 43 N.E.). It runs as a lofty, rampart-like ridge of debris, three-quarters of a mile long, parallel to the scarp, and separated from it by a narrow fosse-like gully. About half-way along its length the top of the mound is eighty or ninety feet above the bottom of the gully, and its sides slope at 30° from the horizontal. At its northern extremity the ridge gradually becomes less bold and soon fades away; at the southern end it merges with the scree. The stream by which the gully is drained has cut a gap through the ridge and shows that it consists of angular and subangular pieces of Old Red Sandstone, few being striated and none rounded, with a little loose sandy matrix. Striæ occur along the course of the eastern brook, in front of the moraine, and range from S.30°E. to S.50°E. These seem to have been produced before the formation of the moraine. We may suppose that after the Tawe Valley ice had disappeared, a snow-slope lingered for many years under the great escarpment, and that the scree-material which otherwise would have accumulated at the foot of the latter, was shot down at some distance in advance to form the ridge of Fan Fechan.

Occasional blocks of the green sandstone and conglomeratic cornstone characteristic of the Senni Beds are to be met with in the Tawyneu valley ; one, eight feet long, lies in the railway-cutting 250 yards south of Nant Lloi, and several others occur on the east side of the valley as far south as Pwll Coediog, where a block six feet in length lies near the house. They are present too in the Tawe valley: in a small wood 150 yards north-east of Dderi; on the valley-side 350 yards north-west of Cerig Haffes ; and on the upper limit of the drift east of Blaen-Car. Outcrops of these green beds occur west of Pont Gihirych in the Crai valley, and at the northern end of Cefn Cûl. From the latter outcrops boulders have been carried by the ice southwards and upwards as far as the summit. Cefn Cûl was thus certainly over-ridden by southward-moving ice, a fact which can only be explained on the supposition that a large body of ice existed somewhere to the north, and to this ice may be attributed the carrying of the cornstone-blocks to the Tawyneu and Tawe valleys. It is not possible to say that there was a southward (upward) movement in the Crai valley ; though the ice on the plateau, as just shown, was travelling in that direction.

The Haffes valley shows a great thickness of till, and the same material overspreads all the lower ground on the limestone-outcrop from the Tawe to the Twrch. Though generally stopping short at the basal scarp of the Millstone Grit, it extends down the Gŵys valley in a continuous tongue into the adjoining sheet of the map. The highest parts of the Cribarth ridge are strewn with Old Red Sandstone boulders. Patches of till with striated stones occur far up the Haffes and Giedd valleys, and in a hollow at the head of the Twrch at a height of 2,050 feet and within 300 yards of the edge of the great escarpment. Numerous striated areas on both sides of the Giedd show that the ice-flow was nearly south, that is, in the direction of the neighbouring valleys. The basement-conglomerate of the Millstone Grit everywhere presents bare glaciated dip-slopes, bevelled crags and *roches moutonnées*. Though slightly diverted westwards by the great ridge of Cribarth, the striæ, when followed north-westwards, gradually become more southerly. On both sides of Cefn-mawr the lower parts of the Giedd and Gŵys valleys show good sections of till, mainly composed of Millstone Grit and Old Red materials, and in the latter valley well-striated limestone-boulders occur. In the former several well-marked drift-mounds or small drumlins having their long axes parallel to the direction of ice-flow are indicated by lettering on the map.

The Vale of Neath (northern side), the Dulais and the Tawe Valleys.

By A. STRAHAN.

The patches of Boulder Clay between Pont-nêdd Fychan and Aberpergwm, while containing much local Coal Measure material, show a purplish tinge and an abundance of boulders of Old Red Sandstone, Carboniferous Limestone and Millstone Grit. They form relics of what has been a thick and continuous sheet and still retain a thickness of sixty feet in places. Striæ running S.10°W. occur in an old quarry on the west side of Nant-y-Gwyddel.

A sheet of Boulder Clay, covering several square miles between the Nêdd and Colbren Junction, consists of a series of low ridges all arranged with their longer axes in the direction of glaciation. The streams for the most part run westwards along the intervening hollows, but occasionally break across them as in the case of Nant-hir at Doledd. All except the Llech fall into the Perddyn and are carried back to the Nêdd. The Boulder Clay, which is frequently seen to a depth of forty feet in the ravines, is red towards its northern part but assumes a blue tinge on and south of the outcrop of the shales of the Millstone Grit. Boulders of Old Red Sandstone and Carboniferous Limestone abound everywhere. Striæ running S.10°W. occur in a stream-bed 300 yards north-west of Cefn-gweny-nawg.

On Hir Fynydd, which separates the Vale of Neath from the Dulais valley, there are deep cwms to which the Brecknock ice seems to have been unable to gain access. That the patches at Aberpergwm are attributable to that ice has already been shown, and the same description applies to two small relics on the south-eastern slope of Graig-lwyd. The striæ on the plateau above the crag, at a height of 1,450 feet above the sea and of 1,300 feet above the valley, have already been mentioned as part of the proof that the Brecknock ice filled the vale to overflowing.

Notwithstanding this fact, in a deep recess to the west of Graig-lwyd, overhung by Graig-lwyd-fechan and drained by Rheola Brook, we find a Boulder Clay entirely devoid of boulders of Old Red Sandstone, Carboniferous Limestone, and even the ubiquitous Millstone Grit. It is a tumultuous deposit of morainic type, upwards of sixty feet thick, and contains many scratched stones, but nothing but what may have been derived from the walls of the cwm itself. Towards its southern margin, where it passes from under the shelter of the hill-shoulder, Brecknock boulders make their appearance in it at a height of about 800 feet above the sea. Another example presents itself in the ravine of Garwed Brook near Pen-craig-nêdd. The Boulder Clay, though of small extent, is upwards of fifty feet thick. It extends from the 800-feet down to the 500-feet contour, and is devoid of Brecknock boulders as far down as the 600-feet contour.

Due west of the last-mentioned patch, and at a height of 980 feet above the sea, there is a large glaciated rock-surface. The striæ occur only a few yards west of the water-parting between the Neath and Dulais, and run S. 34° W. along it. They are obviously due to the Brecknock flow and confirm the conclusion drawn from those on Graig-lwyd, that the Vale of Neath overflowed. It would appear, therefore, that the hollows drained by Rheola and Garwed brooks must have been occupied by local ice during the whole period of existence of the Brecknock flow.

The same description applies to the drift of the Dulais valley. Around Seven Sisters it contains much Old Red in a stiff bluish matrix. Passing up the ravine of Nanthir we find 10 per cent. of Old Red, Limestone and Millstone Grit boulders in the drift at Blaen Nanthir, at 850 feet, but only an occasional boulder of these rocks at Bryn-y-garn, where the drift terminates at a height of 1,000 feet above the sea against the north-west slope of Hir Fynydd. The patch at Nant-y-cafn also shows the same gradual diminution in foreign boulders towards its limit on the hill-slope.

The Crynant valley, which cuts into the heart of Hir Fynydd, forms another example of a recess sheltered from the Brecknock ice. Old Red occurs in the Boulder Clay and coarse gravel which underlies Crynant, but in a side ravine at Blaen-nant becomes scarce, though the Boulder Clay is opened to view to a depth of fifty feet. Five hundred yards higher up the main stream there is a great cascade, where the river passes from a rock-bed on to drift, the latter apparently having been banked against a precipitous rock-slope to a thickness of about 150 feet. Above this again rain-gutters show forty feet of Boulder Clay, in which only one or two blocks of Old Red Sandstone could be found. Here at a distance of one mile from Crynant, and at a height of 900 feet above the sea, we reach the limit of foreign boulders, the drift further up containing local Coal Measure detritus only. Most of the deposit here, as in the other cwms, may be described as a tumultuous assemblage of blocks of almost all sizes, in all positions, angular or partly worn, and often ice-scratched. On the north bank of the stream at the 1,000-feet contour there is a little lenticular seam of bedded loam, sand, and gravel in the Boulder Clay, the gravel being partly cemented by iron. Such lenticles are not uncommon, but are rarely visible.

It is interesting to contrast the drift which lies on the open top of Mynydd-y-Drum west of Henllan, with that of the recess just described. Having been open to the Brecknock flow, the former contains an abundance of Old Red Sandstone.

Here we enter the Tawe valley, and resume the description of the drift which extends from the Neath drainage across the waterparting near Colbren. At Penrhos the Boulder Clay contains numerous boulders of Old Red Sandstone and Carboniferous Limestone, even up to its limits on Mynydd-y-Drum at 850 feet above the sea, and the same remarks apply to a number of drift-ridges which run along the south side of the valley past Abercraf and Glyn-llech. At Abercraf where the valley trends nearly east and west, the drift-ridges take the same direction, but a mile below and at Glyn-llech above, where the valley diverges seriously from the general direction of the glaciation, the ridges take an independent course, the Glyn-llech ridges, in fact, being continuous with those which cross over from the Neath watershed. As will be shown later, however, the Tawe valley at Penwyllt was sufficiently deep to cause a considerable deflection in at least the lower layers of the ice.

Pebble-gravels appear in considerable quantity along the bottom of this part of the valley, with their usual irregular and moundy form. The valley no doubt formed the site of important effluents from the ice-sheet.

In this neighbourhood there occurs an excellent example of a great transported mass, a small hill in fact, of grit. Three others are known in South Wales, namely a small grit-hill cut through in the Sirhowy reservoir,* a crag in the Rhondda-fach valley known as Castell Nos, and a mound near Llannon (Sheet 230). The last two, however, are of uncertain origin. The mass in question has been cut through by the Neath and Brecon Railway, two miles south of Penwyllt. It forms a small but conspicuous eminence on the hill-side, and might have been taken for rock-in-place, had not the cutting revealed the fact that the slightly broken Millstone Grit of which it consists is underlain by Boulder Clay crowded with well-glaciated blocks of Old Red Sandstone, Carboniferous Limestone, and Millstone Grit.

In crossing the Tawe valley at Penwyllt, where it runs north and south, opportunity may be taken of observing its effects on the direction of glaciation. Striæ on the Millstone Grit south of Penwyllt Station show that the normal south-westerly direction was maintained up to the edge of the valley, but that a nearly south trend was enforced within it. Again to the west of the river, 400 yards west of the Vicarage, striæ point almost south, while a mile lower down where the valley turns westward, some well-scratched surfaces, 300 yards north-west of the Ancient Briton Inn, show a corresponding change in the direction of the striæ. That the lower layers only were thus deflected may be inferred from the fact that ice in bulk crossed the Tawe and Neath water-parting on the one side and passed along Cribarth on the other, in both cases in the normal direction.

The rocky northern sides of Cribarth bear conspicuous traces of the passage of the Brecknock ice. The faces of the vertical grits are horizontally grooved and their ridge-like tops beveled and scored from end to end, the direction of glaciation having happened to agree with the strike of the rocks.

The Boulder Clay along Nant Ceiliog and the neighbouring part of the Tawe is packed with great boulders of Millstone Grit, with many of Old Red Sandstone and Carboniferous Limestone. It forms indefinite mounds, ranging in the direction of transport, and an occasional ridge having the aspect and meandering form of a moraine. One such occurs on the east bank of the Giedd two-thirds of a mile north of Tir-y-cwm; it appears to consist principally of large subangular blocks of grit.

North of the Old Red Sandstone Escarpment.

By T. C. CANTRILL.

In the north-eastern part of the map the heads of several of the valleys draining the northern slopes of the Fan range come within the area under description. The drift in them consists of accumulations of more or less angular debris derived exclusively from the dominating Brownstone escarpment. Striated stones are rare, the glacial origin of the deposits being evidenced rather by the moundy disposition of the material. This is the case at the heads of Cwms Cwareli and Oergwm. At the source of Nant Cynwyn a low ridge, slightly convex to the north, encloses a small peat-flat (Sheet 213), probably once a small lake. The enclosing ridge may be either a true corrie-moraine or scree accumulated at the foot of a snow-slope.

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* The Country around Abergavenny (*Memoir Geol. Survey*), 1900, p. 94.

A much finer example of the same phenomenon occurs at the foot of Craig Pwllfa. Here a crescentic moraine, with the convexity pointing down stream, crosses the cwm at the head of a small brook. It consists of angular Old Red debris, and some of the ground enclosed by it is occupied by low dome-shaped mounds. Three small streams escape from the enclosed area, and the westernmost, by cutting a gap through the ridge, has shown it to consist of marl-debris with angular pieces of sandstone, a few being subangular and slightly scratched. The inner face of the south-eastern part of the moraine is so steep as to be devoid of vegetation, and at each end the mound becomes double.

A similar crescentic moraine lies at the foot of the escarpment, where the Gyrfanell descends from the plateau of Gwaen Cerig Llwydion. This mound encloses a peaty swamp.

Though lying in Sheet 213, beyond the northern margin of the map, it may here be observed that the three small lakes, Llyn Cwm Llŵch at the foot of the Brecon Beacons, and Llyn-y-Fan Fawr and Llyn-y-Fan Fâch below the Carmarthen Fans, are all due to glacial action. The morainic character of the material surrounding Llyn Cwm Llŵch was recognised by the Rev. W. S. Symonds,* and the lake and the conditions under which it may have been formed have since been described in greater detail by Mr. Mellard Reade.† It is a small tarn retained by debris-mounds, in places double, and lies at the foot of a steep escarpment. Llyn-y-Fan Fawr lies at the base of the great scarp of the Banau Brycheiniog, the northern extension of Fan Hîr. The water is retained by an apron of debris which spreads out from the foot of the scarp. The river Tawe now rises as a mere runnel on this drift-apron; it is probable, however, that in pre-Glacial times the river arose from springs at the foot of the scarp, and ran north-eastwards along a channel now buried under the drift. The present effluent of the lake—Nant-y-Llyn—issues at its south-eastern angle, and pursues a south-easterly course. After a rapid descent down the side of the main valley, it joins the Tawe two and one third miles below the present source of that river.

Another example of a crescentic mound has been noticed in the head of Nant-y-cadno, half a mile north-west of Llyn-y-Fan Fawr; others less definite occur below Bwlch Blaen Twrch and onwards as far as Llyn-y-Fan Fâch. This lake is dammed on one side by morainic material, and on the other is shut in by the steep rock-slope. Whether or not there is a rock-basin it is impossible to say, either here or in the case of the other lakes referred to. Its effluent forms the river Sawdde.

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* 'Records of the Rocks,' 8vo. *London*, 1872, p. 247.

† *Proc. Liverpool Geol. Soc.*, vol. vii (1894–5), p. 270.

A patch of drift on the west side of Nant Bwrefwr contains striated stones, and the surface is moundy.

Glyn Tarell forms the continuation of Cwm-Tâf Fawr, and gravelly till more or less moundy extends from the head of the one valley into that of the other. A small swamp occupies the top of the pass at a height of 1,440 feet above the sea, and from a spring fifty yards west of the old Blaen Tâf turnpike house, two small runnels arise; one flows north-westwards into Glyn Tarell and the other south-eastwards into the Tâf. The most interesting glacial relic hereabouts is a series of parallel compound ridges lying at the foot of the cliffs which overhang the Tarell valley on the south-west side at the distance of a mile north-west of the Storey Arms. The innermost ridge, which encloses a small peat-flat shown on the map, curves round at its north-west end and runs up the slope towards the cliffs. Where cut through by a sharp bend on the Brecon road, it consists of sandy material with sub-angular and sub-rounded stones, many of which are of green sandstone. This rock, blocks of which are abundantly scattered over the surface of the foremost ridge, crops out between the main road and the peat-flat, at about sixty feet above the surface of the ridge. As the angle of descent is only about 3°, it seems to follow that much of the material, in at least the foremost mound, could not have been mere scree shot down at the foot of a snow-slope, as the outcrop of the green sandstone would lie buried under the snow. It is therefore likely that the snow or ice had a motion of its own, and swept forward blocks of the sandstone from its outcrop to their present position on the mound.

The drift of Glyn Senni forms a strip with indefinite upper limits on each side of the valley, and consists of the usual gravelly till. At the foot of the great and precipitous escarpment forming the northern face of Fan Nêdd, we might have expected a good example of lake and moraine. There are compound ridges and a crescentic mound, but they are not conspicuously developed.

The upper parts of the Crai valley are devoid of drift except immediately north of Bwlch Pen Rhûdd, where the pass is occupied by a large and elongated mound of debris which may be of glacial origin. Lower down the valley drift appears and runs up Nant Gihirych. In the main valley a cutting on the main road just south of the railway-bridge (Sheet 213) west of Nant Gihirych shows sandy debris full of sub-rounded stones chiefly of green sandstone. On the eastern side of the cutting an exposure, about a square yard in area, of green sandstone presumably in place projects through the drift and is striated in a north-east and south-west line, but there is no evidence as to the direction of flow of the ice. The banks of the Gihirych show good sections of similar gravelly till.

The cwm on the north side of Fan Gihirych contains a peat-flat, once probably a small lake, enclosed by a low and irregular mound.

POST-GLACIAL AND RECENT.

River Terraces and Deltas (northern part).

By T. C. CANTRILL.

Along the lower courses of many of the larger streams occasional terraces of sand and well-rolled gravel, generally coarse and with little matrix, occur between the recent alluvium and the glacial drift.

In Glyn Collwng an uneven terrace of coarse gravel rises several feet above the low-level alluvium, and merges into a delta at the mouth of Nant Cynhafen. The delta thrown down by the upper part of the Tâf Fawr, where it enters the pass at the Storey Arms, has been already mentioned; very little engineering would divert the stream from the Tâf valley into that of the Tarell. Lower down the Tâf valley at Nant-ddu a small terrace of coarse gravel fifteen feet high occurs on both sides; it runs some little way up the tributary of that name, and at the mouth of Nant Llysieuog it merges with the delta of that stream. A better example, the surface of which rises twenty feet above the low-level alluvium, borders the river Dringarth north of Ystradfellte; a smaller terrace may be seen on the Nêdd at Blaen-Nêdd-isaf.

At the confluence of the Tawe and Tawyneu valleys there is a delta, and another, rising eighteen feet above the alluvium, at the mouth of Nant Byfre. The delta of the Haffes, across which the river wanders in two branches, is unusually extensive, and has evidently resulted from the re-excavation of the drift-filled valley. Below the gorge of the Tawe at Craig-y-nôs two well-marked terraces border the alluvium.

The probable mode of origin of these gravels seems to be as follows. On the shrinking of the ice the bottom and to some extent the sides of the valley were left lined with morainic drift with a more or less moundy surface. But the melting of the ice would give rise to rapid and powerful streams which would be capable of eroding and transporting much of the drift-material from the upper parts and sides of the valley, and spreading this out farther down stream as a well-washed coarse gravel and sand deposit, with the nearly flat surface characteristic of alluvial formations. The stream subsequently, as the deepening of the valley progressed, would re-excavate much of this gravel and leave fragments as terraces, at the same time that it widened out the recent alluvial flat.

Deltas of the Vale of Neath.

By A. STRAHAN.

The Vale of Neath assumes the form of a flat-bottomed trench where its upper tributaries, the Sychnant and Mellte, fall into the line of the Neath Disturbance. For a mile a coarse gravel-terrace borders the river, while an alluvial flat is in process of formation at a lower level. Lower down the alluvial flat widens out and assumes a steady gradient down the valley, its height above the sea being 240 feet at Pont-nêdd Fychan, 200 feet at Glyn Neath, 150 feet at Aberpergwm, 100 feet at Rheola and about 70 feet at Resolven. Through all this part of its course the valley is overhung by steep hill-sides, more or less encumbered by drift. A series of torrential streams has cut ravines in this and other loose material, and each stream has shot coarse gravel in the form of a delta upon the alluvial flat of the Neath. The deltas being a few feet higher than the flat have been utilised for building at Pont Whalby, Resolven and elsewhere. They are still growing, for at Resolven it was noticed by Mr. Gibson that an iron trough by which the Clydach is carried over the railway has to be cleared of gravel and large blocks after every flood. A similar deposit at Ynys-onws near Pont Whalby is due to an artificial cause. When the ironstone was worked on the hillside above it was customary to clear the outcrops by "hushing" or "sluicing," that is by damming up the surface-water and allowing it to escape with a rush.

In sinking one of the piers of the Terra (Tyrau) Bridge on the Great Western Railway half a mile above Resolven Station, the following section was proved in the river-bed within a few yards of an exposure of solid rock.

At Terra Bridge.

(Communicated by Mr. E. H. LLOYD.)

Water-level 5 feet above the surface :—	FT.
Coarse gravel	20
Fine black sand	15
Fine red sand	35
Hard sand, probably on rock	
	70

Peat.

Small peat-bogs occur on the outcrops of all the shaly strata, as well as in the hollows between the drift-mounds, but have seldom been utilised. Much of the Old Red Sandstone plateau also is covered with hill-peat up to a great elevation; here as in other parts of the country trunks of trees, chiefly the Silver Birch, occurring in places where no trees now grow. Among the more extensive bogs may be mentioned those lying on the Boulder Clay west of Hirwaun, on the Millstone Grit of Cefn Cadlan, on the grits and shales near Gwaen Hepste, on the same strata near Maes-y-gawnen, on the Boulder Clay and Coal Measures around Onllwyn, and on the Boulder Clay which covers the limestone in the Haffes and Giedd valleys. Peat has been dug for fuel west of Nant-ddu in Cwm Tâf Fawr.

Landslips.

By T. C. CANTRILL.

On the north side of Glyn Collwng above the Capel the southerly dip of the beds has caused a landslip of the Brownstones, and tumbled masses of rock extend down the side of the valley as far as the edge of the alluvium. Another slip occurs one and a half miles to the north-west, below the crag of Cwâr-y-Gigfran. A smaller example is to be seen on the western banks of the Tâf Fawr above the Storey Arms, while a fourth is well shown on the eastern side of Fan Dringarth. Two small slips occur in the Tawyneu valley: one south of Bŵlch Pen Rhûdd is shown on the map; the other and smaller one lies on the opposite side of the valley at the southern end of Cefn Cûl. In both cases the slip is due to the beds dipping towards a synclinal axis which follows the valley.

CHAPTER VIII.

ECONOMIC PRODUCTS.

By A. Strahan.

Lime and Limestone.

The principal limestone-quarries occur at Vaynor and Morlais; at Twynau-gwynion the rock is quarried for the Dowlais Iron Works. The varieties of limestone are described on pp. 21, 22. At Penderyn the upper beds, consisting chiefly of light-coloured oolites, are burnt for lime, while some dark-grey limestones below them are used chiefly for road-metal and ballast. The limestone in Cefn has been quarried for the construction of reservoirs in the Taff Valley. The extensive quarries at Penwyllt are mentioned on p. 35, and the old works on Cribarth on p. 36,.

Rottenstone.

This material is being dug south of Penwyllt (p. 35), on Cribarth. and westwards along the top of the limestone as far as the Giedd. It occurs as thin bands in shale, and when followed down more than about eight feet below the surface is found to pass into hard dark limestone. The supply, therefore, is limited to what can be dug out along the outcrop. The old holes where it has been worked or sought for extend westwards from Penwyllt, but not eastwards, in which direction neither the shales nor the rottenstones are known to exist. The stone is got by small open holes, and is left in lumps to dry on the hillside. The best quality is said to fetch £10 a ton.

The following analyses were made by Dr. Pollard to ascertain, if possible, what occurred in the conversion of the black limestone into rottenstone. He reports as follows :—

Bulk analyses of three samples from workings south-west of Cwm Haffes were made, together with analyses of the residue obtained by boiling with dilute hydrochloric acid for about three minutes.

Sample 1. Limestone which on weathering yields rottenstone.
„ 2. Rottenstone of inferior quality.
„ 3. Rottenstone of the best quality.

Parts of the residue from Sample 1 were examined under the microscope, and found to contain minute cubes and apparently spheres of pyrites. The spheres may only be coated with pyrites.

The coarser constituents of Sample 3 obtained by washing, by decantation with water, showed no cubes. Spheres were there, but of an iron-red colour, presumably due to ferric oxide from the oxidation of the pyrites. After this residue had been boiled with dilute acids, the spheres were no longer visible, the red colour had disappeared, and all that remained seemed to consist of a micaceous mineral and some cryptocrystalline silica.

Sample 1 examined in thin section under the microscope was described by Dr. Flett as follows :—

E. 3401. South-west of Cwm Haffes, Glyn Tawe.

> " A fine-grained dark limestone without organic structures, and consisting of small irregular grains of calcite, the surfaces of which are coated with brown films of limonite or organic matter, or both. A few very small cubes of pyrites and flakes of colourless mica are the only visible impurities. There is no detrital quartz, and the silica shown in the analysis must exist as a thin framework of chalcedonic character between the calcite grains."

> " Some best quality rottenstone, when powered, showed under the microscope very fine grains of crystalline silica."

The following are the results obtained by analysis of the three samples named :—

1. Limestone which on weathering yields rottenstone.
2. Rottenstone of inferior quality.
3. Rottenstone of the best quality.

	1	2	3
SiO_2 - - - - -	16·50	70·87	80·82†
TiO_2 - - - - -	·07	·55	·29
Al_2O_3 - - - - -	1·25	9·78	5·82
Fe_2O_3 * ‡ - - - -	·50	4·61	3·79
CaO - - - - -	44·00	1·60	1·43
MgO - - - - -	·69	1·32	·88
CO_2 - - - - -	34·86	·27	Not found
P_2O_5 - - - - -	·36	1·39	1·36
FeS_2 ‖ - - - - -	·32	Not found	Not found
Na_2O - - - - -	Trace	56	·30
K_2O* - - - - -	·32	2·43	1·40
H_2O 105° - - - -	17	2·18	1·27
H_2O above 105° - - + Organic Matter - -	1·31	4·62	2·82
Total - - -	100·35	100·18	100·18

The percentage of insoluble residue (prepared by boiling in dilute hydrochloric acid, etc., and igniting) =

18·75 85·18 88·65

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* Traces of MnO and Li_2O in all three.

† Less than 1% of colloid silica in No. 3.

‡ All Fe calculated as Fe_2O_3.

‖ S in 1 mostly as pyrites but probably a little pyrrhotite. All calculated as pyrites.

and the composition of these residues, expressed in percentage of the residue—

	1	2	3
SiO_2	88·14	83·20	91·17
TiO_2	·39	·64	·33
$Al_2 O_3$	6·75	10·36	6·01
Fe_2O_3 *	2·58	1·92	·69
CaO	·12	·23	·65
MgO	·73	·89	·70
K_2O	1·70	Only estimated in bulk, not in residue.	
Na_2O	Trace.†		

The analysis of the second quality rottenstone (Sample 2) is not really comparable with Samples 1 and 3. The much larger amount of alumina in the residue and the alkalies of the bulk, being so much higher than in Sample 3, seem to point clearly to there being more clastic material (micaceous minerals are recognisable in all three samples under the microscope) than in the other specimens. It will, therefore, not be considered further in detail.

On the other hand, Samples 1 and 3 are distinctly comparable. In the following table Sample 1 has been re-calculated after elimination of all lime and carbonic acid, and as much magnesia as is required by the excess of carbonic acid; all moisture and organic matter and the pyrites calculated to Fe_2O_3. It should be remarked, in connection with Sample 1, that no high accuracy can be placed on even the first decimal, as after elimination of the above-mentioned constituents (roughly 80%) the amount of original substance taken for analysis would be represented by about ·2 gramme.

In Sample 3 lime, moisture, and organic matter have been eliminated.

One hundred parts would therefore contain—

	1	3	Difference.
SiO_2	84·03	85·47	1·44
TiO_2	·36	·31	·05
$Al\ O_3$	6·35	6·13	·22
$Fe_2\ O_3$	3·61	4·00	·39
MgO	2·19	·93	1·26
P_2O_5	1·83	1·41	·42
Na_2O	Trace	·32	·32
K_2O	1·63	1·43	·20

From these figures it will be seen that Samples 3 and 1 are almost identical.

---

* All iron calculated as Fe_2O_3.

† = less than ·05%.

What has happened is that the carbonates have been extracted from the limestone by weathering, leaving behind the siliceous matter which makes "rottenstone." It is also clear that nothing has been introduced during the process of weathering, nor has anything, except the carbonates and sulphur, been removed.

The value of the rottenstone appears to be due to a high percentage of siliceous material in a fine state of division.

Silica Sand.

The more highly siliceous bands in the Millstone Grit are quarried at Dowlais, in Penderyn-foel, at Craig-y-Dinas, in the Nêdd Valley above Pont-nêdd Fychan, between that place and Pont Whalby, and near Penwyllt, for making the well-known Dinas fire-bricks. Sand derived from the disintegration of the mass of grit referred to on p. 47 is dug for the same purpose at Pwll Byfre. At Dinas the best stone for making silica-bricks is known as "good blue" and contains about 96–97 per cent. of silica, with not more than ½ per cent. of lime or ½ per cent. of iron, the remainder being alumina. It has a pale-blue tinge and breaks down readily into powder. After being crushed it is ground up with milk of lime, moulded and burnt for six days, at a temperature which is said to reach 4,000°F. The stone is a conglomerate of pebbles of vein-quartz in a grit-matrix, but the pebbles break down as readily as the matrix. The following notes on the microscopic characters are furnished by Mr. Teall.

E. 3049. Millstone Grit, Dinas; used for fire-bricks and known as "good blue."

Fine-grained grey quartzite traversed by a thin quartz-vein.

M. Composed of quartz-grains and grains of crypto-crystalline or micro-crystalline silica (chert ?). The average size of the grains is about .3 or .4 mm. The original grains of quartz have been enlarged by the deposition of secondary silica. There are no signs of crushing in this rock. *Quartzite.*

E. 3050. Millstone Grit forming the face of a fault at Bwa Maen (p. 41).

A coarse-grained grit containing well-rounded pebbles up to 12 mm. in diameter.

M. This is also composed of quartz-grains and grains of crypto-crystalline or micro-crystalline silica; but there are decided traces of crushing. Some of the quartz-grains show moiré-structure under crossed nicols, others have been more or less granulitised.

Building Stones.

The Llynfi Rock is quarried near Dyffryn for building purposes. The character of this rock, as it occurs in the Aberaman, Coed-cae, and Dowlais quarries, is described in "The Country around Pontypridd and Maesteg" (*Memoir Geol. Survey*), 1903, pp. 122–3.

Some hard siliceous sandstones in the limestone of Penderyn (p. 23) have been used under the name of Welsh Stone for viaducts, etc., around Aberdare.

Road Metal.

The harder and darker limestones are used for road-metal, as remarked above. The basal grit of the Millstone Grit is quarried for the same purpose near Cefn.

Water Supply.

The water-supply is derived from springs and from the impounding of surface-water in reservoirs, not from deep wells. Much of the water impounded is carried far beyond the limits of the area under description. The Tâf Fawr reservoirs provide part of the supply for Cardiff, and the water from the Crai Valley will be carried to Swansea by a tunnel driven through the water-parting into the Tawe Valley. The Tâf Fechan Valley is utilised for the supply of Merthyr, and works in the Dringarth Valley are in contemplation.

The outcrop of the more shaly parts of the Millstone Grit forms the site of reservoirs for the Dowlais Works and for Aberdare. A reservoir for the supply of Pontypridd has recently been constructed on the Pennant at the head of the Rhondda-fâch.

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